

# MANAGEMENT OF MAMMAL COLLECTION in Tropical Environment



# Management of Mammal Collection in Tropical Environment

Proceedings of the Workshop on Management of  
Mammal Collection in Tropical Environment held  
at Calcutta from 19th to 25th January, 1984.



*Edited by the Director*  
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## FOREWORD

The 'First International Workshop on the Management of Zoological Collections : Recent Mammal Collections in Tropical Environment' was held in Calcutta from 19th to 25th January, 1984, under the auspices of the Zoological Survey of India, Calcutta and the Carnegie Museum of Natural History, Pittsburgh, U.S.A.

The objective of the Workshop was to discuss ways and means for the management of mammal collections under tropical environment in the context of the present-day knowledge, so as to improve upon the existing procedures.

To achieve this goal, scientists from 11 countries of the tropical region and of USA discussed various aspects of collection-management namely, collecting and labelling, preservation, storage, management, pest-control, computerisation of collection data, etc. A total of 42 papers were presented. At the end of the Workshop the outcome of the discussions in various sessions led to a number of recommendations which are appended at the end of this volume for the benefit of institutions which maintain mammal collections.

An editorial committee, comprising Dr. V. C. Agrawal and Shri P. K. Das from the Zoological Survey of India and Drs. H. H. Genoways and D. A. Schlitter from the Carnegie Museum of Natural History, was constituted for processing the papers and seeing through the publication of this volume. These gentlemen have devoted much of their time to edit the contributions and I am glad that they have done their job in the most befitting manner for which they deserve sincere thanks.

Calcutta,  
29th December, 1988

Dr. Asket Singh  
Scientist SF-In-Charge  
Zoological Survey of India



## PREFACE

The First International Workshop on the Management of Zoological Collections, concentrating on Recent Mammal Collections in Tropical Environment, was a landmark event. Held at Calcutta, January 19—25, 1984, it brought together two great organisations— the Zoological Survey of India and the Carnegie Museum of Natural History— and provided an effective forum for the dissemination of information and exchange of ideas on a common theme. Observations from participants, both from the two organising groups and from external participants, attest to the success of the Workshop and to the desirability of continuation of such a programme with varying venues and organisers.

The American contribution to the Workshop was led by the Section of Mammals, Carnegie Museum of Natural History, Carnegie Institute, Pittsburgh. Dr. Duane A. Schlitter and Dr. Hugh H. Genoways devoted enormous amounts of time and energy to the project, collaborated extensively with their Indian colleagues, and mobilised not only the resources of Carnegie Museum of Natural History but also mammalogists and collection specialists from across America. They also helped the Zoological Survey with the task of selecting and inviting foreign delegates who could both contribute to and benefit from the Workshop.

The Special Foreign Currency, administered through the Office of Grants and Contracts of the Smithsonian Institution, played the pivotal role of providing financial support for both the American delegation and participation in the Workshop of the numerous non-Indian delegates. This assistance was essential to the entire programme, and all beneficiaries of the Workshop, both participants and those who will use the extensive information in this volume of papers presented at the Workshop, owe a deep debt of gratitude to the Smithsonian Institution.

The idea to organise such a Workshop arose out of a visit by Drs. Duane A. Schlitter and Hugh H. Genoways of the Carnegie Museum to the Zoological Survey of India in December 1982. These two gentlemen were in close touch with Dr. V. C. Agrawal and Shri P. K. Das, mammalogists in the Zoological Survey of India. During their visit to Calcutta, they had an elaborate discussion with Dr. K. C. Jayaram, Joint Director and Dr. A. K. Ghosh, Scientist 'D'. A Memorandum of Understanding was drawn up and the preparations for the Workshop thus began.

The Government of India in the Department of Environment kindly arranged for the release of the PL 480 funds to the tune of 65,000 US \$ and also granted a sum of Rs. 1.30 lakhs in Indian Rupees towards this Workshop.

The proceedings of the Workshop were held in the beautiful premises of Ramakrishna Mission Institute of Culture at Gol Park, Calcutta, where most of the foreign delegates were also housed. The Workshop was divided into six Sections and each was opened with a special lecture. A field trip to Araku valley, Andhra Pradesh was organised. A panel of recommendations were drawn up.

A total of 43 participants attended, of which 24 were from abroad representing 11 countries. India was represented by 19 scientists. The Workshop was inaugurated by Shri Digvijay Sinh, the then Deputy Minister for Environment and the Valedictory function was chaired by Prof. R. Natarajan, Director, Centre of Advanced Studies in Marine Biology, Porto Novo.

The Workshop though a maiden attempt for the Zoological Survey of India in respect of organising an International meet of this kind was a grand success as evidenced by the unsolicited appreciations received following the Workshop. The untiring efforts of several months made by the team of staff of Z.S.I. and listed elsewhere, are mainly the contributory factor for the success of the Workshop. However, certain names have necessarily to be mentioned because they were mainly instrumental in co-ordinating the diverse aspects of the Workshop and ably and effectively meeting the several needs that arose from time to time. Dr. K. C. Jayaram, Joint Director took a heavy burden in this respect and is due the deserving thanks and warm appreciation. Drs. A. K. Ghosh, Scientist 'D', V C. Agrawal, Scientist 'C', P. K. Das, Scientist 'C' in a like manner shared many responsibilities. Shri S. Sivagurunathan, Publication Production Officer, with his staff undertook the onerous task of getting the different literature of the Workshop elegantly printed and issued. Drs. O. B. Chhotani, Scientist 'D', R. K. Kacker, Scientist 'C' with his team of staff from the Photography Section, Dr. Kuldeep Rai, Scientist 'C', Dr. J. K. Jonathan, Scientist 'C', Dr. J. R. B. Alfred, Scientist 'D', Dr. R. C. Basu, Scientist 'B', Dr. J. K. Sen, Scientist 'C', Shri Sukumar Banerjee, Scientist 'C', Shri S. M. Ali, Scientist 'C', Dr. S. Chakraborty, Scientist 'B' and Shri Biswanath Roy rendered assistance in various ways. To all these gentlemen and several other staff of the Z.S.I. not mentioned here we express our sincere heartfelt thanks.

Dr. T N. Khoshoo, the then Secretary, Department of Environment, actively supported the programme and assisted at critical times with

his ready advice and positive response. Shri K. B. Iyer, Director, Department of Environment, Shri K. V Mahalingam, Dy. F.A. responded to our requests promptly without which the smooth functioning of this programme would not have been possible. We are deeply indebted to Hon'ble Shri Digvijay Singh, former Deputy Minister, for his continuous encouragement and support.

Lastly, to all the participants, particularly to those from abroad our thanks are due for co-operating whole-heartedly which has made this experience a very memorable one.

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## SCOPE OF THE WORKSHOP

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The idea for an International Workshop on 'Management of Zoological Collections : Recent Mammal Collections in Tropical Environments' was developed during the organisation of a workshop on "Mammalogical Museum Collections", held at the Third International Theriological Congress in Helsinki, Finland, in 1982. It became apparent during the planning of that workshop that many of the people in charge of mammalogical collections throughout Africa and southern Asia would not be able to travel to Finland. The workshop in Finland, although successfully completed, focussed primarily on collections of the temperate areas of North America and Europe.

Because the staff of the Section of Mammals, Carnegie Museum of Natural History, has had a long-standing interest in the technology of collection management, Dr. Duane Schlitter and I decided to try to organise a workshop that focussed on problems encountered in maintaining collections in tropical environments. Much of our own research is centred in tropical areas ; therefore, we have a natural interest in these collections. We decided that it would be best to restrict this first workshop to those collections in East Africa, West Asia, South Asia and Southeast Asia. This would restrict the logistical problems in gathering a group of scientists for such a workshop. India, a leading nation in this region, was a logical location. During our previous visit to India, our proposal for such a workshop was warmly received by Dr. T N. Khoshoo, Secretary of the Department of Environment, and Dr. B. K. Tikader, Director of the Zoological Survey of India. It is only through their continued active support and the tireless planning efforts of Dr. K. C. Jayaram, Joint Director of the Zoological Survey of India, that we are here today inaugurating this workshop.

It is indeed impressive to find in India the political and scientific leadership that makes possible the formulation of an international scientific conference. We must remember after all, that although the



subject of this conference may seem parochial, the reality is that we are here discussing the preservation of a common heritage for a common good.

The scope of our meeting far exceeds its title. This conference ultimately will have a bearing on such far-reaching subjects as 1) environmental quality, 2) agricultural production, 3) the economy, 4) public health, and 5) conservation of endangered wildlife. We are gathered here because we know that museum collections, are, in fact, an extremely significant resource to planners, scientists, educators, and ultimately to the people themselves. The presence in Calcutta of more than 60 top scientists from 15 countries re-enforces our common belief in the importance of our work, and in my view, is a signal of India's emergence as a technological resource to her neighbours.

The Honorable Deputy Minister Digvijay Singh, Dr. Khoshoo, Dr. Tikader, and Dr. Jayaram are to be congratulated for their farsightedness because surely this conference will become a model of successful international scientific cooperation. Undoubtedly, we are preparing here a foundation for exciting future international research aimed at finding solutions to common problems of humanity.

The focus of this workshop is on collections of animals of the Class Mammalia. These are the animals that are characterised by having hair, at least on part of their bodies, and feeding their young milk. Specimens of mammals may be found as taxidermy mounts, dried study skins, tanned hides, skeletons, skulls, whole individuals stored in formalin or alcohol, and numerous other special preservations, or any combination of these. Because the materials involved are so delicate and the variety of material that must be handled so varied, mammal collections are particularly difficult to manage. Although our focus during the workshop will be on mammal collections, many of the techniques that will be discussed will be applicable to other natural history collections, particularly the vertebrate collections such as those of birds, amphibians, reptiles, and fish.

During this workshop, we will be discussing the management of collections from the methods of acquiring the specimen in the field until the specimen is ready for research purposes in the museum. Our proceedings will begin with the methods of capture and field preparation of specimens. Techniques for preparation of skeletal material are especially critical to our studies because we rely heavily on cranial morphology for identification and comparison of specimens. Methods of cataloguing or registering specimens into the museum's permanent records will be seen

from two points of view. We will be discussing the arrangement and long term maintenance of collections. The latter subject includes prevention of damage to the specimens by insects, dust, light, humidity, and a variety of other physical and environmental factors. The records that accompany the specimens are of equal value to the specimens. These must be managed with equal care and attention to detail. Finally, the success of any collection depends upon strong and wise administration. The administration of collections will be discussed from several different viewpoints. Our discussions will also include detailed consideration of individual collections representing a wide range of histories. These include a very new collection at the University of Addis Ababa in Ethiopia as well as some that date from the early 1800's such as those of the Zoological Survey of India and the National Reference Collection of Singapore.

The tropical environment presents a number of difficult problems for the management of Recent mammal collections. The high humidity and seasonally high rainfall cause problems ranging from mildew to increased mobility of acids in paper and wood. The species of insect pests are different from those in temperate regions and they occur the year around. Therefore, the purpose of this workshop is to present curators with as many proven solutions to problems encountered in collection management as possible. It will be the responsibility of the curators to select those solutions that best fit their own situation and to adapt these methods for their own particular needs.

Although our primary discussions will concern the technology of the management of collections of Recent mammals, we must never forget that the primary purpose of these collections is the production and dissemination of knowledge through research and publication. Science has been developed by human society for the purpose of creating and distributing knowledge. Curators and their collections must be contributors to this increase in human knowledge. The specimens that they accumulate are means to this end. If the specimens are not used as the basis of research and publication, their maintenance becomes only that of operating a warehouse, and the cost of maintenance cannot be justified. However, if the collection is part of an active research programme, the expenses for maintaining them are easily justified.

With each publication, the value of the specimen is increased as it becomes a voucher for this research. One of the basic tenets of all scientific research is that the results of the studies must be repeatable and verifiable. It is the voucher specimens stored in collections that make this possible in any specimen-based research. A unique attribute of museum specimens is that, while they serve as vouchers for previous

studies, they can serve as the raw material for future studies. A specimen is never used up ; its value actually increases with each use.

We, as curators, are charged with preserving voucher specimens which prove the validity of research done by past generations. We also serve as custodians for specimens that provide a basis for studies which are yet to be formulated by future generations. We have gathered here for the next week to discuss, in as much detail as possible, the management of our international resource—collections of Recent mammals.

## **PHILOSOPHY AND ETHICS OF MUSEUM COLLECTION MANAGEMENT**

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### **INTRODUCTION**

Science has been developed by human society for the purpose of creating and distributing knowledge (Anderson, 1985). Curators of mammals and their collections are contributors to this increase in human knowledge. The specimens that they help accumulate and maintain are means to this end. The specimens serve as vouchers (Yates, 1985) for past and current studies and form the basis for further investigations (Anderson, 1985).

It is the specimens that make museum research unique. Curators of collections of mammals may engage in a wide variety of research projects but those that are not based on the specimens in the collection could just as easily be performed by university professors with no available collections. Consequently, curators of mammals should concentrate their research efforts on specimen-based research in order to justify the expenditure of time and effort that is involved in making and maintaining these collection resources (Nicholson, 1983). There can be no doubt that much research on mammals remains to be done in which specimens are essential. This research is to be done in the future by an ever-decreasing number of mammalogists who are trained in whole organism biology (Genoways *et al.*, 1976); therefore, each curator becomes increasingly important.

The types of specimen-based research performed by curators are highly varied as has been discussed in detail later by Schlitter (1988). These may be basic studies with no apparent immediate utility or applied studies with goals directed toward solving a specific problem. However, these collections find their primary utility in studies of identification, taxonomy, and systematics and in mapping distributions and zoogeography of mammals. These studies find their theoretical basis in Darwinian evolution and Mendelian genetics. Evolutionary and distributional studies are primarily basic research. Nevertheless, it must never be forgotten that very little research of any type would be possible



on mammals without proper identification, and any field study of wild mammals requires a knowledge of distributional patterns. Interpretation of the results of comparative studies of mammals are possible only with a thorough knowledge of the relationships of the species involved.

We must remember as scientists that our duty is not only to create knowledge but also to disseminate this knowledge (Colbert, 1958; Ripley, 1973; Nevling, 1983; Nicholson, 1983). The dissemination of knowledge begins with the writing and publishing of scientific papers, but does not end there. Those curators who work in museums with public programmes, have an opportunity to disseminate information on mammals through temporary and permanent exhibitions and participation in educational programmes. However, curators who work at institutions without public programmes still have the responsibility to get the results of their studies the widest audience possible. They may teach at local universities or other schools. They may give limited tours of their research facilities to groups of advanced students. All curators can write and distribute popular literature on mammals. These can range from one page of photocopied information distributed upon request to the beautifully illustrated popular guidebooks as will be discussed later by Mares (1988).

Because the specimens in our collections are what make our research unique, we have organised the "First International Workshop on Management of Zoological Collections : Recent Mammal Collections in Tropical Environment" and this resulting volume. However, before becoming involved in the mechanics of management of collections, we should ask ourselves some questions about why we do, what we do. At the same time, we must examine our personal ethics in dealing with the collection, staff, and public.

## PHILOSOPHY

In this section, three questions that are commonly asked of collection personnel are examined. These questions really go to the heart of reasons for making and maintaining collections.

### *Why Make Collections ?*

The instinct or desire to collect is probably as old as human society (Alexander, 1979; Burcaw, 1975). This desire to accumulate oddities or unique items resulted in the organisation of natural history cabinets as the European nations began to explore the world. The cabinets began to grow beyond the accumulation of uniques into more modern natural history museums with the development of Darwinian evolutionary

concepts of individual and population variation. Thereby, these natural history cabinets have developed into modern natural history museums with extensive collections of the world's flora and fauna.

One of the main, but often not remembered, reasons that collections of mammals are made and maintained is that they preserve a record of the world's mammalian fauna (Ripley, 1973). There are mammals such as the red wolf (*Canis rufus*) in North America, the quogga (*Equus quogga*) in Africa, and Shomburgk's deer (*Cervus shomburgki*) in Southeast Asia which are now extinct and can be seen only in collections of mammals. Many other cases are not as dramatic, but these collections do serve as baseline data for documenting the past distributions of mammals. With the numerous environmental changes, such as the clearing of tropical rainforests and increasing size of deserts throughout the world, the geographic ranges of many species of mammals are changing rapidly. However, without the baseline data in the collections of mammals throughout the world, these changes can not be documented nor their meanings interpreted (Ripley, 1973). These collections should be viewed as records of our national natural heritage that are as valuable as the artifacts of our cultural heritage.

The other primary reason for making and maintaining collections is the obvious one—research (Nicholson, 1983). Specimens that we collect as part of our ongoing studies will serve as vouchers for our work to future generations. Yates (1985) has defined a voucher specimen as “one which serves to physically and permanently document data in an archival report by (1) verifying the identity of the organism(s) used in the study; (2) by so doing, assuring the repeatability of the study which otherwise could not be repeated and/or accurately reviewed or reassessed.” One of the basic tenets of all scientific research is that the results of the studies must be repeatable and verifiable; therefore, if we do not save and maintain the specimens on which our research is based, we are not being scientists.

A unique attribute of museum specimens is that, while they serve as vouchers for previous studies, they can serve as the raw material for future studies. Many of these future studies are not even formulated because we do not at this time have the information to ask the appropriate questions. When I wrote my doctoral dissertation (Genoways, 1973), I used a significant number of specimens which were collected before 1900 and which had been used in a number of previous studies. Therefore, a specimen may serve as a voucher for numerous studies. A specimen is never “used up”; it can provide raw material for countless studies.

To answer the question of why we make collections, I believe the response should be—‘Because we are scientists who must conserve vouchers of our research and who are interested in conserving a record of our national natural heritage.’

### *Why Collect Series ?*

The question that is most commonly asked by members of the general public is—‘Why do you need more than one specimen of any one kind ?’ This is a reasonable question because it would certainly reduce the space and funds necessary to maintain collections, and it would reduce the number of animals being removed from natural populations. It is also a reasonable question because natural science had its origin in such typological thinking before the importance of variability was recognised. I will try to answer this question by telling the following story :

Suppose that you were the mammalogist who arrived on the same alien spaceship as the botanist ‘E.T’ Your mission is to collect specimens of the human race to return to your home planet. How many specimens would you need to collect to represent the full range of variation in the human race? First, we know that members of even local populations exhibit differences. If we travel to Poona, India, or Kent, England, we would find that some people are taller than others, some are fat, some thin, and all variations in between, and some may have light hair while others have dark. This type of variation is termed individual variation.

All of us quickly recognise the primary differences among the sexes, but upon reflection, you can probably also list some differences between the sexes that are not related directly to sexual reproduction. These are secondary sexual differences. Among humans, we know that males are generally larger and have a more robust build than females.

The ontogenic changes of a newborn infant into an adult are well understood by anyone who has watched a child grow up. Different parts of the body grow and develop at different rates as the body progresses to its adult size. In scientific studies, this is called age variation.

These three types of variation are present in any population of humans and they are present in all populations of wild mammals. Before we can assess the final type of variation within a species, we must have a thorough knowledge of individual, secondary sexual, and age variations. To be able to assess these types of variation, we need large series of individuals from relatively restricted areas.

It does not take a trained systematist to recognise that humans living in Uppsala, Sweden, look different from those living in Nairobi, Kenya, Beijing, China, or the native Americans from Pine Ridge, South Dakota. This is geographic variation. This is usually assessed by comparing adults of one species from one area with adults of the same species from another area. When significant secondary sexual variation is present, males and females are analysed separately. To do studies of geographic variation, series of individuals are needed from throughout the geographic range of the species. We must have a thorough understanding of geographic variation before we can start describing differences among species.

We see, therefore, that our alien mammalogist is faced with a rather large task. A large series of individuals from several local populations must be collected to assess the individual, secondary sexual, and age variations in humans. Furthermore, series from throughout the Earth must be obtained to assess geographic variation. He will need to return to his home planet with at least several hundred specimens to be able to accurately evaluate variation in the species. This is exactly the logic that all mammalogists use when planning studies of wild mammals, and is the reason that series of mammals must be collected and maintained. These studies of variation are basic to any understanding of identification, taxonomy, and systematics.

I have heard it stated that we really do not need to collect large numbers of common species for our collections, the logic being that because they are common, there is little left to be learned about them. However, the exact opposite may be closer to the truth— we probably need to concentrate more of our efforts on common species. No one likes to find a new species or a specimen of a rare species more than I do, but the common species are the ones which will most likely be of economic importance, and will be most important to non-mammalogists. It is often possible to get samples of sufficient size of common species to do detailed analyses of variation, which may never be possible with rare species; therefore, it is possible to develop a better understanding of the systematics and evolutionary history of these commoner species.

There are numerous examples in the literature where studying widespread species, utilising new techniques and specimens in collections, reveals that we have a great deal more to learn about such species. My colleagues and I have been studying short-tailed shrews (genus *Blarina*) for nearly 20 years. This shrew is a common inhabitant of most habitats in eastern North America, and in many places it is the commonest small mammal present. Remains of these animals are commonly found in Pleistocene and Holocene deposits where these shrews are used to interpret



the paleoclimate. Since the genus was last revised in 1895 (Merriam, 1895), two species were recognised—one with a range over the eastern half of North America (*B. brevicauda*) and one restricted to coastal Virginia and North Carolina (*B. telmalestes*). The species with the restricted distribution has been shown to be a subspecies of *B. brevicauda* (Handley, 1979), whereas our work (Genoways and Choate, 1972; Genoways *et al.*, 1977; George *et al.*, 1981, 1982; Moncrief *et al.*, 1982) has shown that at least four, and possibly more, species are present in what was previously considered to be *B. brevicauda*. This new insight was made possible by using new techniques, such as karyology and electrophoresis, while studying museum specimens of *Blarina*.

The black rat, *Rattus rattus*, is a common inhabitant of the Old World and has been transported throughout the world by human activity. In eastern and central Asia, the black rat has a karyotype of  $2n=42$ , whereas in western Asia, Europe, and Africa, this species has a  $2n=38$  (Niethammer, 1975). The  $2n=38$  form is the one which has been transported to North and South America, Australia, and New Zealand (Davis and Baker, 1971, and citations therein). It has been suggested that these chromosomal forms are distinct species, but this will not be proven until the contact zones between these forms have been intensely studied. These two forms come together in southern India where a karyological study would answer questions about the systematic relationships of these chromosomal races.

The house mouse, *Mus musculus*, has a nearly worldwide distribution because it is a highly successful commensal with man. It is a common experimental animal in biomedical research. The house mouse native to Europe, Africa, and Asia has been believed, until recently, to belong to a single species, *Mus musculus*. However, recent chromosomal studies by Capanna and others (Capanna *et al.*, 1977; Capanna, 1980, and citations therein) have shown that this is really a complex of closely related species. Species such as *abbotti*, *castaneus*, *domesticus*, *hortulanus*, *poschiavinus*, and *spretus* are now being considered as distinct from *Mus musculus* (Honacki *et al.*, 1982; and citations therein). Clearly, much more work remains to be done to carefully document the exact relationships of these taxa and to map the distributions of the newly recognised species. These examples should clearly indicate that no matter how common and well known a species of mammal is, we can still learn more about it.

The answer to our original question—‘Why collect series?’ is because series are necessary to study all types of variation. An understanding of variation is required for any study involving identification, taxonomy, or systematics, and as stated previously, these studies are basic to most research on mammals.

A related question that is often asked is—‘What constitutes a sufficient sample size ?’ This is a question with no precise answer because so many variables are involved. However, there are some general guidelines that can be followed when conducting multivariate analyses of geographic variation. Each sample will ideally consist of 20 adult specimens, but 10 can be considered minimal. If secondary sexual variation is present, then these sample sizes would be necessary for both sexes. Obviously, one or more of the samples will need to be much larger (50 to 75 individuals) so that individual, age, and secondary sexual variations can be assessed. The samples should be located about every 160 km throughout the geographic range of the species. The samples would need to be much closer together if we are in zones of primary or secondary contact or at the boundaries between nominal subspecies. It is clear that few, if any, species are presently represented in collections to such an extent. Only the commoner species will ever be so well represented, but we should strive towards this ideal situation as we build our collections.

#### *How Are Collections Maintained ?*

This is the question that is the focus of this entire book. However, there are some basic principles that we should consider. These were eloquently discussed by Joseph Grinnell in 1922. He stated that every collection was in need of a “special type of curator who has ingrained within him the instinct to devise and put into operation the best arrangement of his materials— who will be alert to see and hunt out errors and instantly make corrections— who has the *museum conscience*”

In Grinnell’s opinion, the museum conscience rested upon a careful regard for accuracy and order when working with the collection. Grinnell did not advocate a particular way to order the collection, but he felt any system should be simple and clear. The order was to apply not only to the specimens, but also to all associated data and materials. It is the responsibility of the curator to select the system which best fits his situation. Throughout this book, curators are presented with alternative methods for managing collections. All of these are solutions that have worked in other collections, but none are considered to be “better” than others ; this is for the curator to decide. Once the order to be used is selected, the curator’s job is not done. He must see that it is put into operation for all materials in his care. As Grinnell (1922) pointed out, “Any fact, specimen, or record left out of order is lost”

The accuracy of data published on collection materials depends upon the accuracy of the data associated with the specimens. This

begins with specimen labels and field notes made at the time the specimen is obtained and prepared. These are the primary sources of information about the specimen and should serve as the ultimate authority for checking all other data. Field collectors must check and recheck the specimen labels and field catalogs to insure the accuracy of these primary sources of information. When these primary sources of information are transcribed to secondary sources such as catalogues, handwritten card files, or computerized data banks, the work should be done by a staff member who has an appreciation for the need for accuracy and who understands how these data will ultimately be used. The curator should establish a system of checks and rechecks for the accuracy of all materials in the collection. Members of the staff should be made to understand that their work will be rechecked by someone else. No one, including the curator, is perfect, so there should be no one exempted from the system.

Any curator who has established a system for his collection, sees that the system is implemented for all materials, and works to insure the accuracy of all data, will successfully maintain his collection regardless of the specific techniques or systems that are used. He will have the 'museum conscience'

## ETHICS

Members of the museum staff, just as members of any other profession, are regulated by the ordinary rules of moral conduct that govern all human interactions (Constable, 1941). However, beyond these ordinary constraints, there are special ethical considerations that curators and other collection staff must follow in their relations with other museums, other museum staff members, the public, standards of maintenance of the collection, and compliance with legal regulations. In the following sections, each of these areas of ethical consideration are examined in more detail.

### *Standards for Curators*

The standards in this section are directed primarily toward curators, but many of these standards will also apply to other staff members working with the collection. The standards that apply to these other staff members depend upon the scope of their responsibilities with the collection. However, when ethical questions arise in a collection of mammals, the curator of mammals will be the final authority and will bear the final responsibility.

There have been numerous attempts in the past to try to codify standards for curators and other museum staff (Swinton, 1958; Douglas, 1967; Hairston, 1970; Zelle, 1972; Anonymous, 1974; Bostick, 1974; Mead, 1978; Malaro, 1979; Phelan, 1982). The latest and by far the most complete of these was published by the Curators Committee of the American Association of Museums (Lester, 1983). These ethical standards have been modified in Table 1 so that they apply directly to collections of mammals.

The curator of mammals must be directly involved in the acquisition of all specimens of mammals for his institution (Colbert, 1958). It does not matter what the source of the material is, whether it is direct acquisition from field studies, deposition of voucher specimens from other scientists, or a gift. It does not matter what the ultimate use of the specimen will be, whether it is for research, exhibition, or education. The curator is best qualified to determine the utility of specimens and their value to his collection. This also gives the curator the opportunity to determine if the specimens were obtained legally before they become the property of the museum. When receiving gifts, the curator must try to obtain the specimens with no restrictions. However, if this is impossible, he must see that all parties involved understand the restrictions, and he must determine if these restrictions are in the best interests of the museum.

One of the primary ethical responsibilities of a curator is for the maintenance and safety of the collections. He must keep the collections in order (Grinnell, 1922) so that they can be easily studied. If the collections are not kept in order, the collection becomes just a storehouse; the specimens can not be used for the benefit of the museum, nation, or mankind. The obvious safety hazards for the collection are theft and mechanical breakage. However, there are also long-term considerations for the safety of the specimens from insect pests, dust, light, and pollutants. These conservation and preservation concerns for mammal specimens are only now becoming the subjects of study (Hawks, 1988).

Curators must avoid all situations where there is a potential for a conflict of interests, or the appearance of a conflict of interests. For curators of Recent mammal collections, this includes avoiding making personal collections of mammals. The curator with a personal collection is always faced with the question of where new and exciting specimens are deposited. The curator will not be tempted to collect "after hours" or "on weekends" for his personal collection while on museum-sponsored field trips. Curators should never acquire items that have previously been the property of the museum. Appraising items for people outside of the museum including donors should be avoided because of

the potential for conflict of interests. In the United States, the Internal Revenue Service will not accept for tax purposes appraisals of donations made by staff members of the institution which is the recipient of a donation.

Curators must do research on the collections (Nevling, 1983; Nicholson, 1983). It is impossible to justify the expense of making and maintaining collections if they are not studied by the collection staff. This research is a primary source of information on the natural history, systematics, zoogeography, and evolution of mammals. This primary information forms the basis for secondary uses such as educational programmes, formal teaching, and exhibition. Because curators generate the primary information, they must involve themselves in the dissemination of this information in secondary and tertiary uses. Within the museum, the curator of mammals must be responsible for the scientific accuracy of all information that is disseminated on mammals (Colbert, 1958).

### *Standards for Collections*

Because the specimen and its associated tags are the ultimate source of information for collection data and all studies are based upon the collection, it is incumbent upon the staff of the collection to give their maximum attention to the care of the specimens. The American Society of Mammalogists (Anderson and Choate, 1974; Choate, 1978), recognising the need for quality care of collections, established a set of minimum standards for collection maintenance (Malaro, 1979). The Systematic Collections Committee, which has been responsible for the implementation of these standards, has worked closely with the individual curators. The emphasis of this Committee's work has been to aid collections to meet these standards. The committee wants the list of collections meeting the standards, which is published periodically in the *Journal of Mammalogy*, to be inclusive rather than exclusive. The ideal situation would be to have all collections of Recent mammals meeting these standards. This is the only way to insure the future availability of the specimens upon which all museum research rests.

Because these standards established by the American Society of Mammalogists are really the only attempt to codify standards for maintenance of collections of mammals (Black, 1975), they are worth a closer look. The entire set of standards are listed in Table 2.

The collection must be under the direction of a professional mammalogist. This is someone who depends upon the collection as a research resource and whose future employment depends upon the maintenance

of the collection. No particular academic degrees are indicated, but a scholarly attitude towards the collection is intended.

The specimens must be protected from mechanical and pest damage. This is accomplished through housing specimens in an adequate museum building and in adequate storage cases. No specific standards are set but these must protect the specimens from the normal physical dangers such as fire, water, dust and light. The entire science of mammalogy is hurt when a collection such as the one in the Museu Bocage, Lisbon, Portugal, is destroyed by fire. Collections must be protected against insect pests that are able to destroy specimens.

Because the most important part of the specimen for research purposes is the skeletal material, its preparation in the laboratory is of particular concern. The recommended procedure is preliminary preparation with dermestid beetle larvae and then soaking in ammonia solution before final preparation. This method is considered to be the best because it can give consistently good results with little or no breakage of delicate areas such as the pterygoid processes and zygomatic arches (Groen, 1988).

The collection must be arranged according to a specific plan, because as pointed out by Grinnell (1922) any collection that is not in order is not usable. The exact plan is not important, although it should be as simple as possible, but the plan must be rigidly enforced throughout the collection.

The data and tags associated with the specimen are of equal importance to the specimen. The curator must give these items equal attention, particularly to insure their accuracy. It is also important that these ancillary data are cross-referenced to the specimen so that all information about a specimen can be easily accessed. The best way to cross-reference material is with field numbers and museum catalogue numbers.

The data suggested for inclusion in the permanent catalogue (catalogue number, genus, species, sex, method of preparation, and country, states and date of capture) are the minimal amount that should be used. It is particularly important that more detailed locality information be included as well as the collector's name and field number. There are other items that individual collections will want to include depending upon their needs (McLaren, 1988).

The collection must be accessible to qualified users because a collection that is not being used is not justified. However, access of unqualified users must be rigidly controlled and can be allowed only under direct

supervision of a staff member. The use of the collection by qualified scientists may take place either at the site of the collection or on loan. When specimens are sent on loan, they are particularly vulnerable to loss or damage. Extreme care should be taken to properly label and pack parcels that contain loan shipments.

The curator must be certain that all specimens entering the collection are obtained in a legal manner. This is the subject of the following section.

### *Legal Considerations*

In recent years, curators have been faced with an escalating number of laws and regulations which concern the collection, export, import, exchange, and loan of museum specimens. Staying abreast of new laws, changes in the old laws and regulations, and obtaining of the necessary permits to conduct field research are taking an increasing amount of the curator's time. Nevertheless, if a curator is to meet his legal and ethical obligations, he must be certain that each specimen in his collection is obtained and handled in a legal manner.

In many countries, the collecting of mammals is controlled at the state, provincial, or other local level, whereas in some countries, this is handled at the national level. In the United States, each of the 50 states controls the collecting of mammals within its boundaries (McGaugh and Genoways, 1976; Berger and Neuner, 1981). The import and export of specimens are normally handled at the national level. The exact department of the government that will be responsible will differ from one country to another. All imports/exports including loans and exchanges to/from the United States must be accompanied by a declaration of Importation/Exportation of Fish and Wildlife (Form 3-177). Then, depending upon the material being imported/exported, permits may be needed from the Department of the Interior, Department of Commerce, Department of Agriculture, or Department of Human Services (Genoways and Choate, 1976; Phelan, 1982). In other countries, the permits may be issued by the Department of the Environment, Department of Agriculture, or Department of Forestry; it depends upon which department is responsible for renewable natural resources within the country. The point that a curator must keep in mind when planning field work is that permits will be needed to collect and import/export mammals in most countries. The exact authority to issue these permits will vary from one country to another, but it is the responsibility of the curator to determine permit issuing agency and to obtain the appropriate permits before work begins.

The most important legal agreement at the international level is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) signed on 3 March 1973 in Washington, D. C. This convention sets the rules for the international movement of listed species among countries who are party to the convention. Three levels of protection were given to species to be covered by the Convention.

Species believed to be threatened with extinction, which are or may be affected by trade, are listed on Appendix I of the Convention. The trade of specimens of these species is particularly restricted so as not to further endanger the survival of the species in the wild. An export permit is required from the country of origin of a specimen of any species listed on Appendix I. This permit is to be issued only after the Scientific Authority of the State has certified that export of the specimen will not be detrimental to the species in the wild and the Management Authority of the State is satisfied that the specimen was taken in accordance with the laws of the State. The import of any specimen of a species on Appendix I requires an import permit. The import permit will be issued only when the Authorities in the importing country agree with the decisions of the exporting country. Re-exporting a specimen requires a re-export permit under the same conditions as the original export permit.

Appendix II contains species that are not immediately threatened by extinction but may become threatened unless trade is restricted. This list may also contain certain look-alike species. The export of specimens of species on Appendix II requires an export permit under the same conditions as those listed on Appendix I, but an importation permit is not required. Re-exportation does require a permit.

Appendix III includes all species which any Party to the Convention identifies as needing regulation within its jurisdiction for the purpose of controlling exploitation, particularly as the result of international trade. The export of a specimen of a species included in Appendix III from any State which has included that species in Appendix III requires an export permit. An import permit is not required, but a re-export permit is required.

Curators must remember that these regulations apply to any movement of CITES-listed species whether it is the original collecting or whether the specimens are being re-exported as a loan or exchange. However, these regulations only apply to CITES-listed species (Berger *et al.*, 1979; Tikader, 1983) and not to all species of mammals and these regulations apply only if one of the States involved is a Party to the Convention.



The Management Authority of States that are Party to the Convention do have the authority to grant exemptions for non-commercial loan, donation, or exchange between registered scientists or scientific institutions of museum specimens. For example, the Fish and Wildlife Service of the Department of the Interior issues such permits in the United States (Berger and Gatchell, 1980). These permits allow the institutions to carry on international loans and exchanges of CITES-listed species. The parcels containing the specimens must be labelled as containing CITES-controlled species and must display the permit number of the institution. Each institution must make a report of all of their activities under the permit each year.

### CONCLUSIONS

As the technical aspects of collection management are discussed in this book, it should never be forgotten that the specimens and their management are only means to an end. This end is research resulting in the creation and dissemination of knowledge. The specimens draw their value from being used in scientific research.

Specimens are not used up, but become more valuable as they become vouchers for more and more studies. This makes those who manage collections responsible to those who have gone before. We must preserve the vouchers of their work to prove the validity of the work to future generations. At the same time, we serve as custodians of these specimens to future generations because this material will serve as a basis for studies which are yet to be formulated. Therefore, it is the responsibility of managers of collections to give their collections the most professional care possible.

### SUMMARY

Curators of mammal collections are scientists who are responsible for the creation and dissemination of knowledge about mammals. Their research is unique because it is specimen based. The specimens are a resource that curators must maintain as vouchers of past studies and as the raw material for future investigations.

It is important for those people who care for collections to understand why collections are made, why series are collected, and how to care for collections. Collections are made because it is necessary to conserve vouchers from specimen-based research so that this research is repeatable and verifiable in the future. Collections also preserve a record of mankind's natural heritage. Series of each species of mammal are

preserved in collections because an understanding of variation in populations is required for any study involving identification, taxonomy, or systematics, which are basic to most research on mammals. Curators should be most concerned with the order and accuracy of their collections and associated materials.

The curator of mammals will be the final authority when ethical questions arise concerning the collection and he will bear the final responsibility. Areas of ethical concern are personal conduct and work, standards for the collection, and legal questions about the acquisition and handling of the specimens. These ethical standards apply not only to curators but to anyone working with the collection. The scope of their responsibilities with the collection will determine which standards should be of concern to them.

#### REFERENCES

- ANDERSON, S. 1985. Developments in information retrieval systems. *Acta zool. fenn.*, 170 : 61-63.
- ANDERSON, S. and CHOATE, J. R. 1974. Report and recommendations : Advisory Committee for Systematic resources in mammalogy, American Society of Mammalogists. *Am. Soc. Mamm.*, 30 pp.
- ALEXANDER, E. P. 1979. *Museums in motion*. American Association for State and Local History, Nashville, Tennessee.
- ANONYMOUS. 1974. Code of ethics for museum workers. *Mus. News*, 52 : 26-28.
- BERGER, T. J. and GATCHELL, D. D. 1980. *Index to U. S. Federal Wildlife Regulations : An Annotated Reference* (1980 ed.). Ass. Syst. Colln., Lawrence, Kansas.
- BERGER, T. J. and NEUNER, A. M. 1981. *Directory of State Protected Species : A Reference to Species Controlled by Non-Game Regulations* (1980 ed.). Ass. Syst. Colln., Lawrence, Kansas.
- BERGER, T. J., NEUNER, A. M. and EDWARDS, S. R. 1979. *Directory of Federally Controlled Species* (1979 ed.). Ass. Syst. Colln., Lawrence, Kansas.
- BLACK, C. C. 1975. Report of the ASC Council on Standards for Systematics Collections. *ASC Newsl.*, 3 : 1-4.

- BOSTICK, W. A. 1974. The ethics of museum acquisition. *Museum*, **26** : 26-33.
- BURCAW, G. E. 1975. *Introduction to Museum Work*. American Association for State and Local History, Nashville, Tennessee.
- CAPANNA, E. 1980. Chromosomal rearrangement and speciation in progress in *Mus musculus*. *Folia Zool.*, **29** : 43-57.
- CAPANNA, E., CIVITELLI, M. V and CRISTALDI, M. 1977. Chromosomal rearrangement, reproductive isolation and speciation in mammals : The case of *Mus musculus*. *Bull. Zool.*, **44** : 213-246.
- CHOATE, J. R. 1978. Revised mammal standards, and the systematic collections that meet them. *J. Mammal.*, **59** : 911-914.
- COLBERT, E. H. 1958. On being a curator. *Curator*, **1** : 7-12.
- CONSTABLE, W. G. 1941. Museum ethics. *Mus. News*, **18**(19) : 9-12.
- DAVIS, B. L. and BAKER, R. J. 1971. Chromosome morphology of North American *Rattus rattus* (L.) (Muridae). *Cytologia*, **36** : 417-420.
- DOUGLAS, R. A. 1967. Museum ethics : practice and policy. *Mus. News*, **45**(5) : 18-21.
- GENOWAYS, H. H. 1973. Systematics and evolutionary relationships of spiny pocket mice, genus *Liomys*. *Spec. Publs. Mus.*, Texas Tech Univ., **5** : 1-368.
- GENOWAYS, H. H. and CHOATE, J. R. 1972. A multivariate analysis of systematic relationships among populations of the short-tailed shrew (genus *Blarina*). *Syst. Zool.*, **21** : 106-116.
- GENOWAYS, H. H. 1976. Federal regulations pertaining to collection, import, export, and transport of scientific specimens of mammals. *J. Mammal.*, **57** (suppl. 2) : 1-9.
- GENOWAYS, H. H., CHOATE, J. R., PEMBLETON, E. F., GREENBAUM, I. F. and BICKHAM, J. W. 1976. Systematists, other users, and uses of North American collections of Recent mammals. *Museology*, Texas Tech Univ., **3** : 1-87.

- GENOWAYS, H. H., PATTON, J. C. III, and CHOATE, J. R. 1977. Karyotypes of shrews of the genus *Cryptotis* and *Blarina* (Mammalia : Soricidae). *Experimentia*, **33** : 1294-1295.
- GEORGE, S. B., GENOWAYS, H. H., CHOATE, J. R. and BAKER, R. J. 1982. Karyotypic relationships within the short-tailed shrews, genus *Blarina*. *J. Mammal.*, **63** : 639-645.
- GEORGE, S. B., CHOATE, J. R. and GENOWAYS, H. H. 1981. Distribution and taxonomic status of *Blarina hylophaga* Elliot (Insectivora : Soricidae). *Ann. Carneg. Mus.*, **50** : 493-513.
- GRINNELL, J. 1922. The museum conscience. *Mus. Wk*, **4** : 62-63.
- GROEN, J. A. 1988. Skeletal preparation techniques. *Proc. Wkshp Mgmt Mammal Colln Tropical Environ.* : pp. 141-158.
- HAIRSTON, N. G. 1970. Biological field work. *Science*, **169** : 8.
- HANDLEY, C. O., JR. 1979. Mammals of the Dismal Swamp : a historical account. *The Great Dismal Swamp* : 297-357. P. O. Kirk, Jr. (Ed.), Univ. Press Virginia, Charlottesville, Virginia.
- HAWKS, C. A. 1988. Conservation considerations in Recent mammal collections. *Proc. Wkshp Mgmt Mammal Colln. Tropical Environ* : 475-493.
- HONACKI, J. H., KINMAN, K. E. and KOEPPL, J. W. 1982. *Mammal species of the world*. Allen Press Inc. and Ass. Syst. Colln., Lawrence, Kansas.
- LESTER, J. 1983. A code of ethics for curators. *Mus. News*, **61**(3) : 36-40.
- MALARO, M. C. 1979. Collections management policies. *Mus. News*, **58**(2) : 57-61.
- MARES, M. A. 1988. The need for popular natural history publications concerning mammals. *Proc. Wkshp Mgmt Mammal Colln Tropical Environ* : 439-457
- McLAREN, S. B. 1988. Application of documentation standards and automatic data processing in Recent mammal collections. *Proc. Wkshp Mgmt Mammal Colln Tropical Environ* : 573-599.

- Mc GAUGH, M. H. and GENOWAYS, H. H. 1976. State laws as they pertain to scientific collecting permits. *Museology*, Texas Tech Univ., **2** : 1-81.
- MEAD, G. W. 1978. Museum ethics. *Mus. News*, **56**(2) : 21-30.
- MERRIAM, C. H. 1895. Revision of the shrews of the American genera *Blarina* and *Notiosorex*. *N. Am. Fauna*, **10** : 5-34.
- MONCRIEF, N. D., CHOATE, J. R. and GENOWAYS, H. H. 1982. Morphometric and geographic relationships of short-tailed shrews (genus *Blarina*) in Kansas, Iowa, and Missouri. *Ann. Carneg. Mus.*, **51** : 157-180.
- NEVLING, L. I., JR. 1983. No longer the hidden agenda : research goes public. *Mus. News*, **62**(1) : 42-45.
- NICHOLSON, T. D. 1983. The obligation of collecting. *Mus. News*, **62**(1) : 29-33.
- NIETHAMMER, J. 1975. Zur Taxonomie und Ausbreitungsgeschichte der Hausratte (*Rattus rattus*). *Zool. Anz.*, **194** : 405-415.
- PHBLAN, M. E. 1982. *Museums and the law*. American Association for State and Local History, Nashville, Tennessee.
- RIPLEY, S. D. 1973. Museums and the natural heritage. *Museum*, **25** : 10-15.
- SCHLITTER, D. A. 1988. The value of recent mammal collections. *Proc. Wkshp Mgmt Mammal Colln Tropical Environ* : 637-646.
- SWINTON, W. E. 1958. Museum standards. *Curator*, **1** : 61-65.
- TIKADER, B. K. 1983. *Threatened Animals of India*. Zool. Surv. India, Calcutta.
- YATES, T. L. 1985. The role of voucher specimens in mammal collections : characterization and funding responsibilities. *Acta zool. fenn.*, **170** : 81-82.
- ZELLE, A. 1972. ICOM ethics of acquisition : a report to the profession. *Mus. News*, **50**(8) : 31-33.

*Table 1. Code of Ethics for Curators of Recent Mammal Collections  
(modified from Lester, 1983)*

### I. Acquisition and Disposition

1. Curators must be involved with the acquisition and disposition of all mammal specimens.
2. Final decision for accessioning and deaccessioning of specimens of mammals is the responsibility of governing authority of the museum, but with guidance from the curators.
3. Curators must insure that all mammal specimens entering the collection have been collected in accordance with international, national, and local laws.
4. Curators must insure that all gifts of specimens of mammals are unrestricted or that the conditions are specific and accepted by the museum.
5. Curators should never purchase or otherwise acquire for themselves specimens of mammals that have been deaccessioned from the collection.

### II. Field Study and Collecting

1. All field studies and collecting of mammals must be done in accordance with national and local laws.
2. All shipments of specimens of mammals between nations must be done in accordance with provisions of the Convention on International Trade in Endangered Species.
3. When working with endangered species of mammals, it must be remembered that preservation of species in the wild is the highest priority.
4. When on museum-supported collecting trips, all specimens obtained and all photographs and other materials taken are the property of the museum.

### III. Management, Maintenance, and Conservation

1. The curator is responsible for the safety of specimens and associated materials in his charge.

2. The curator is responsible for keeping collection in order.
3. The curator is responsible for ensuring the accuracy of all records associated with specimens.

#### IV Availability of Collections

1. The curator must make the collection available for use by qualified scientists, including filling reasonable loan requests.
2. The curator is responsible for obtaining exhibition material of mammals specifically for that purpose.
3. The curator should establish a separate teaching collection of mammals for training future mammalogists and providing information to the public.
4. The curator should restrict the use of the collection by commercial concerns unless funds are provided that can be used for maintenance of the collections.
5. Curators should be aware that if their collections contain human remains then special handling may be required.

#### V Personal Collections

1. Curators of collections of Recent mammals must not maintain personal collections of Recent mammals.
2. Curators of collections of Recent mammals should avoid maintaining personal collections in disciplines maintained by their museums.
3. Curators should avoid housing personal collections on museum property.

#### VI. Appraisals

- 1 Curators should prepare appraisals of mammals only for internal use at their institution.
2. Curators should never appraise items for outside interests, including for donors of items.

## VII. Responsibilities

1. Curators are expected to perform research on the collections.
2. Teaching, lecturing, and writing are professional responsibilities of curators.
3. Curators may at times do professional outside consulting concerning mammals, but they must be certain that they are not in conflict with their home institutions or that they are not detracting from their primary position.
4. The ownership of the results of the curator's scholarly activities (manuscripts, books, art work, etc.) may be in doubt ; however, the general rule should be that items resulting from work done within the scope of employment and fully funded by the institution are the property of the museum.
5. Curators are responsible for accuracy of information on mammals presented to the public.

## VIII. Relationships

1. Curators owe loyalty to their museums.
2. Curators must carry out their assigned duties and function according to the guidelines established by the institution.
3. Curators employed by the same institution should work in full cooperation toward the goals established by the institution.

*Table 2. The minimal standards for collections of Recent mammals established by the American Society of Mammalogists (Anderson and Choate, 1974; Choate, 1978).*

(1) Collections should be administered by non-profit public or private institutions.

(2) A collection must have at least one professional mammalogist who is directly responsible for it.

(3) Collections must be housed in buildings that provide adequate protection from fire, water, dust, excessive heat or light, and other physical hazards. We recommend that important permanent records (such as catalogues and field notes) be kept in a fireproof or fire retardant safe or its equivalent.



(4) Specimens must be stored in insect, dust, and light proof containers.

(5) Specimens must be periodically inspected and fumigated.

(6) Specimens must be prepared in a manner that insures their utility. It is particularly critical that osteological materials be properly prepared. The use of dermestid beetles and their larvae in cleaning small skulls and other osteological materials is strongly recommended, but dermestid colonies should be located so to prevent infestation of the collection proper.

(7) Specimens must be arranged according to a specific plan that is recorded and, preferably, posted.

(8) Field notes and ancillary data must be preserved as a part of the permanent record for each specimen.

(9) Data on specimen labels, in field notes, in the permanent catalogues, and wherever else data are recorded in the collection must be accurate.

(10) A permanent catalogue of all specimens in the collection must be maintained. The catalogue must include at least the following minimal data: catalogue number; genus; species; sex; country, continent, or ocean of capture; state or province of capture; method of preparation; data of capture.

(11) The collection must be accessible to all qualified users.

(12) Accessibility to collections by unqualified persons must be restricted. We recommend the formation of separate teaching collections for use in basic courses, and the restriction of catalogued specimens for research purposes.

(13) Loans with other institutions must be handled in a professional manner

(14) Type specimens must be identified as such, stored in cases marked accordingly, and made accessible to qualified scientists. They should not be sent on loan.

(15) The institution must intend to continue support of the collection at least at a level necessary to maintain these standards. Should institutional priorities be changed at some future time, the institution should express a willingness to transfer the collection to another public institution which will insure its perpetual maintenance.

(16) Acquisition and possession of specimens of mammals must accord with international, federal, and local regulations pertaining thereto.

## COLLECTION METHODS FOR SMALL MAMMALS

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### INTRODUCTION

Numerous traps and trapping methods have been devised for small mammals over the years. The collector must take many factors into consideration when selecting a particular method for use. What type of trap should be used ? Is it necessary to collect the animal alive ? In what type of habitat will the trapping be done ? What are the weather conditions at the trap site ? Is the collector interested in a particular species, and, if so, what special allowances for behaviour, ecology, physiology, or other factors must the collector make for that species ?

### TRAPS

The first consideration should be the kind of trap to be used. All traps described are summarised in Table 1. When the collector does not need live specimens, the snap or break-back trap is most commonly used. There are three types of snap traps : the Victor rat (176 × 87 mm ; large treadle, very strong spring), the Victor mouse (98 × 46 mm ; small treadle, strong spring), and the Museum Special (138 × 68 mm ; small treadle, light spring). Wiener and Smith (1972) found the Museum Special (Fig. 1) the most effective of these three traps in collecting most species of small mammals. With its lighter spring, the Museum Special is more sensitive to the presence of an animal than is either Victor trap. In addition, the Museum Special has the greatest distance from the treadle to the bar. As a result, skulls are damaged least often with this trap. For the same reason, however, very small animals, such as shrews, often are caught only by the tail, and thus escape. Foster (1945) solved this problem by soldering 20-24 gauge wire across the jaw of the trap. Small animals are caught under this wire, but serious damage to the skulls can be prevented by using a soft metal wire, such as a nickel alloy. Snap traps are often thrown some distance when they go off ; thus it is advisable to tie them to vegetation with string to prevent loss. Wiener and Smith (1972) found that small squirrels were collected equally successfully with Victor rat and Museum Special traps. Because of the larger

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body size of these species, they set off Victor rat traps as easily as they set off Museum Specials. Large squirrels and cricetines such as pack rats require Victor rat traps, as the spring on the Museum Special is not strong enough to kill them.

TABLE 1.—A summary of traps and the animals for which the traps are best suited.

Trap	Live or Kill	Size of Animal	Type of Animal <sup>1</sup>	Comments
Museum Special	Kill	Shrew to small squirrel	T, A, B	
Victor rat	Kill	Mouse to large squirrel	T, A, B	
Victor mouse	Kill	Shrew to mouse	T	
Sherman	Live	Shrew to small squirrel	T, A, B	
Young	Live	Mouse to small squirrel	T, A, B	
Holdenreid	Live	Mouse to small squirrel	T, A, B	
Fitch	Live	Mouse to small squirrel	T, A, B	
Scheffer mouse	Live	Shrew to mouse	T	
Longworth	Live	Shrew to small squirrel	T, A, B	Nest chamber
Buech	Live	Shrew to small squirrel	T, A, B	Nest chamber
Rose/Fitch	Live	Shrew to small squirrel	T, A, B	Nest chamber
Burt	Live	Shrew to mouse	T	Multiple capture
LoBue/Darnell	Live	Shrew to mouse	T	Multiple capture
Brown	Live	Shrew to mouse	T	Multiple capture
Pitfalls	Live, Kill	Shrew to mouse or mole	T, F	Multiple capture
Hav-a-Hart	Live	Squirrel	T, B	
Tomahawk	Live	Squirrel	T, B	
Horn/Fitch	Live	Mouse to small squirrel	T, B	
Snare	Live	Small squirrel	B	
Wobeser/Leighton	Live	Small squirrel	B	
Gen	Live	Small squirrel	B	
Prychodko	Live	Small squirrel	B	
Macabee	Kill	Gopher	F	
Scheffer	Live	Gopher	F	
Ingles	Live	Gopher	F	
Sherman gopher	Live	Gopher	F	
Baker/Williams	Live	Gopher	F	
Victor spike	Kill	Mole	F	
Yates/Schmidly	Live	Mole	F	
Jensen	Live	Mole	F	
Collapsible tube	Live	Mole	F	

<sup>1</sup>T= terrestrial species, A= arboreal species, B= burrowing species, F= fossorial species

Some investigators are interested in taking karyotypes or blood, which requires that animals be taken alive. Innumerable live traps have been designed for small mammals. The live trap most commonly used in North America by museum collectors is the foldable Sherman trap (Fig. 2A). It is constructed of sheets of aluminium, has a floor treadle, and when it is set, only one door is open. Sherman traps are light, can be folded, and thus are easy to carry and set. Because animals sometimes gnaw through the aluminium doors and escape, the doors and treadle may be made of galvanized steel. These traps come in several sizes ; the most commonly used are  $8 \times 8 \times 25$  cm and  $5 \times 6.5 \times 16.5$  cm. Quast and Howard (1953) and Stickel (1948*a*), in comparisons of these two sizes, noted a higher trap success with the larger trap. The treadle in the larger trap can be adjusted to lighter weights than can the treadle in the smaller Sherman. Also, because of the greater length of the larger Sherman, there is a lower probability of catching tails in the door when it shuts. The Young trap (Holdenreid, 1954), in contrast to the Sherman, is made of hardware cloth and both doors are open when it is set ; this allows the animal to see through the trap before venturing into it. In comparisons of the Sherman and the Young traps, Holdenreid (1954), working in desert grassland, found the Young to have higher trap success, whereas Sealander and James (1958), working in forest, found the Sherman to have the higher trap success. Holdenreid (1954) designed a trap using hardware cloth (screen of heavy wire with 5 mm mesh) and a wire rather than a sheet metal treadle (Howard, 1953) ; only one door is open when it is set (Fig. 2B). Fitch (1950) designed another hardware cloth live trap with a wire trigger suspended from the roof rather than the floor of the trap (Fig. 2C). Scheffer (1934) attached a bean-can to the treadle end of a Museum Special, and then soldered wire across the jaw of the trap to fashion an inexpensive live trap (Fig. 2D).

One major problem with these live traps is that in cold or wet weather, survivorship may be significantly decreased. The traps of hardware cloth afford no protection from inclement weather. Nesting material may be put in Sherman traps to add insulation, but this tends to foul the treadle and the traps must be cleaned before they can be re-used. Chitty and Kempson (1949) designed the Longworth trap with a wire treadle and a nest chamber attached at the rear (Fig. 3A). The rear chamber may be stocked with food, water, and nesting material. In comparison of Longworth to Sherman live traps Morris (1968) found a slightly higher trap success for cricetines and microtines with Shermans. Crowcroft (1951) and Grant (1970), however, found that very small mammals, such as shrews and juvenile mice, were more easily caught in the Longworth traps, which are capable of being set for lower weight animals. Buech (1974) designed another metal live trap with a built-in nest chamber that, with its wire trigger, is capable of capturing smaller animals at an even greater rate than the Longworth (Fig. 3B).

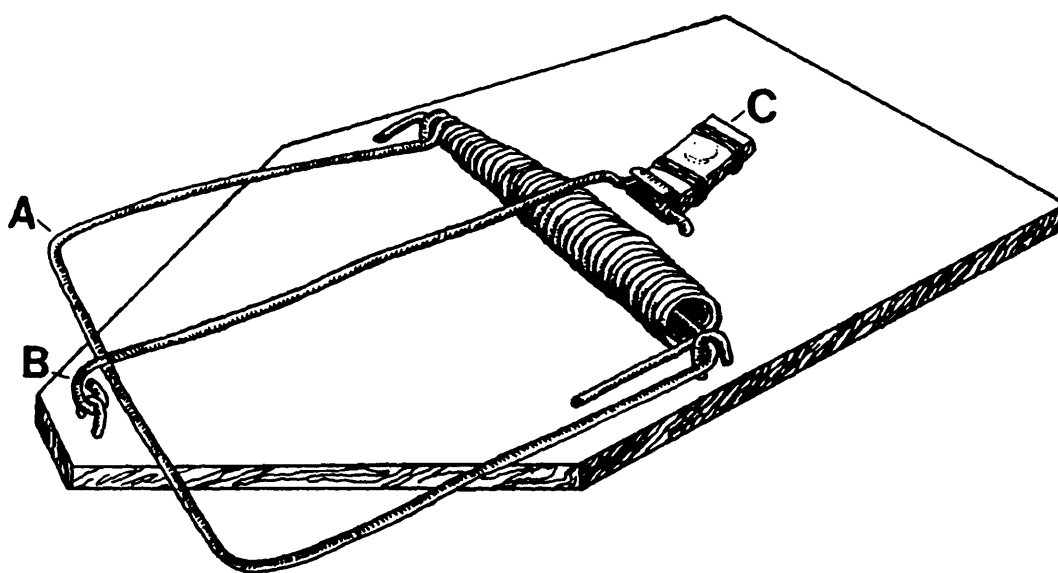


Fig. 1.—Museum Special Trap, shown set. The break-back bar (A) is held poised by a stiff wire (B), which fits under the lip of the treadle (C). The bait is set on the treadle.

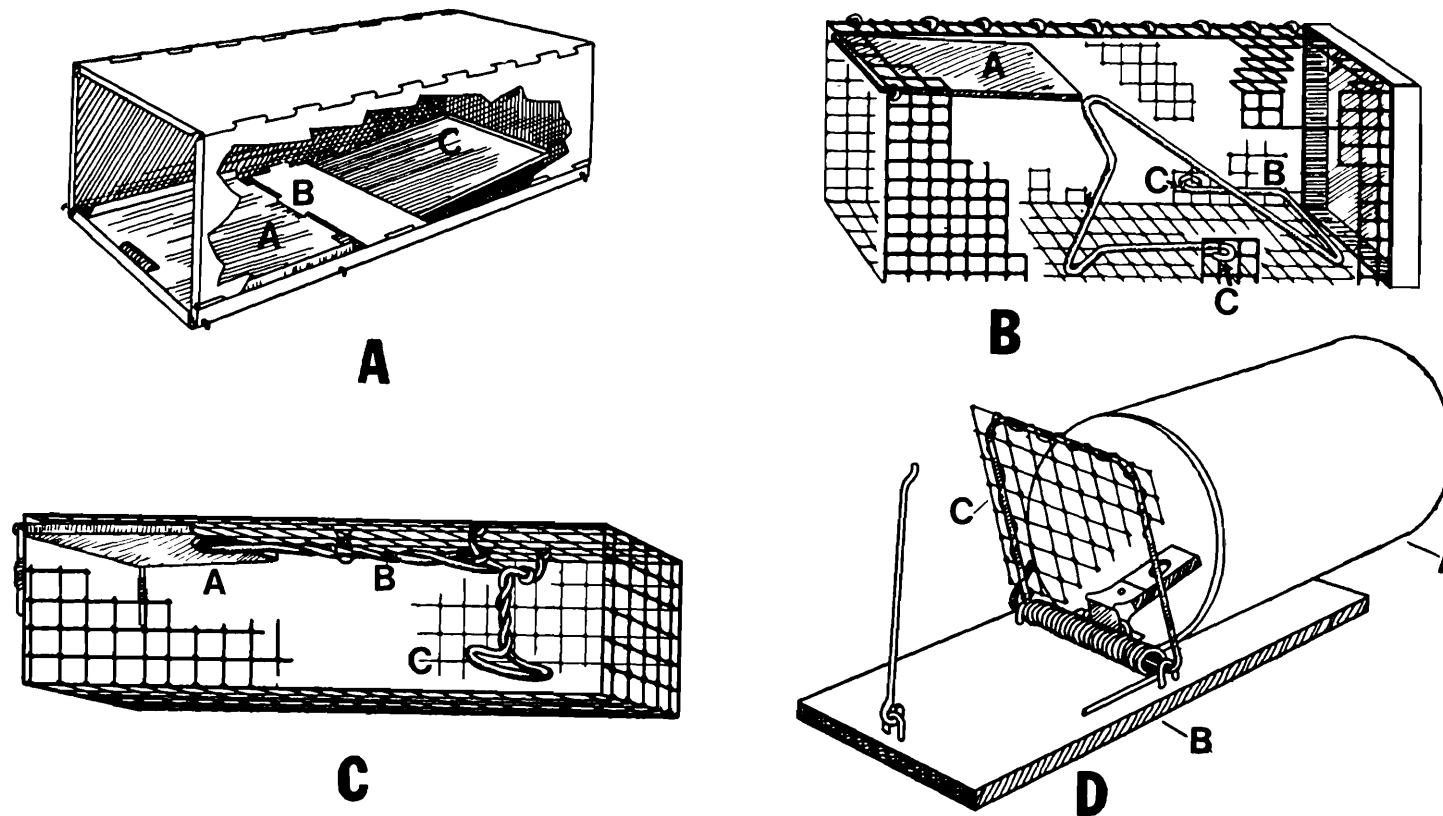


Fig. 2.—A. Sherman foldable live trap, shown set with side cut away. Door (A) is held open by a catch (B) attached to the treadle (C). Dry bait is tossed in the rear of the trap.

B. Live trap designed by Holdenreid (1954) and Howard (1953), shown set. Door (A) is held open by wire trigger (B). Ends of the wire are wrapped around the mesh to hold the trigger in place (C). Modified from a figure in Howard (1953).

C. Fitch (1950) trap, shown set. Door (A) is held open by wire (B) attached to wire trigger (C). Modified from a figure in Fitch (1950).

D. Live trap designed by Scheffer (1934). Small can (A) is attached to a Museum Special trap (B). Escape is prevented by covering the bar with mesh (C). Trap is set as in Fig. 1. Drawing from Scheffer (1934).

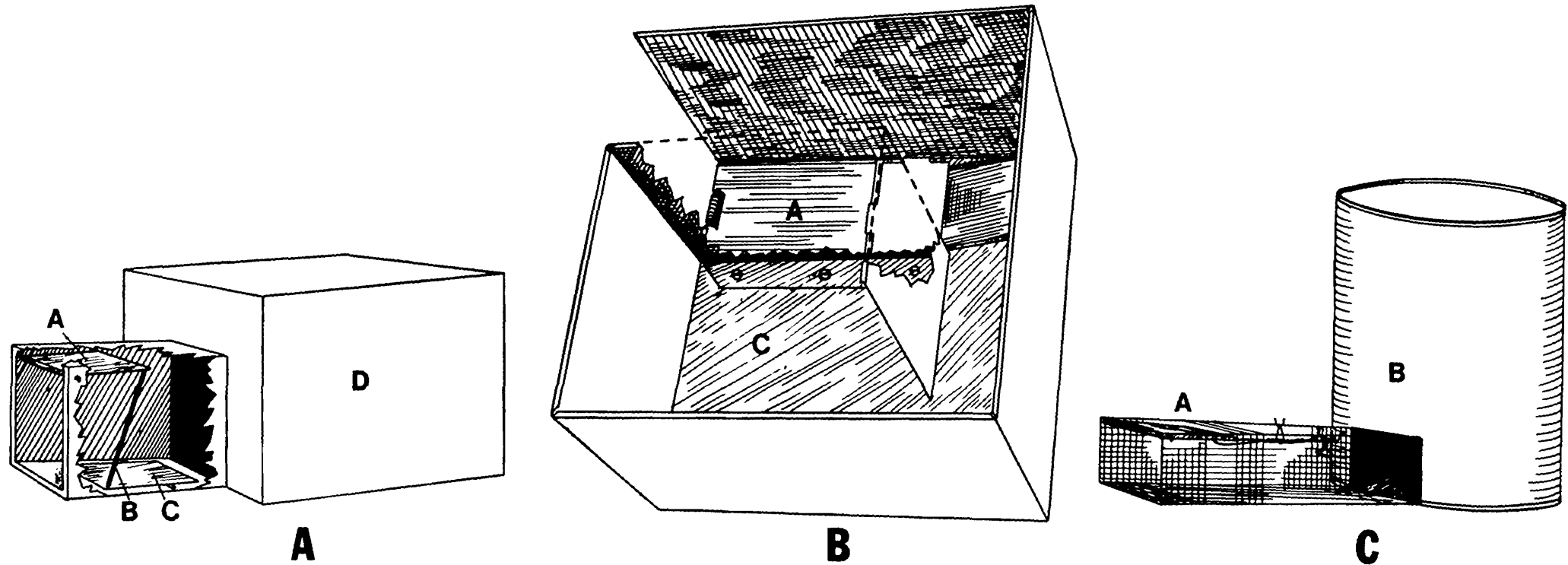


Fig. 3.—A. Longworth trap designed by Chitty and Kimpson (1949), shown set with side and roof cut away. Door(A) is held open by stiff wire (B), attached to wiretrigger plate (C). Nest chamber (D) is attached to the rear of the trap ; for storage, the trap may be put inside the nest chamber. Modified from figures in Chitty and Kempson (1949).

B. Live trap designed by Buech (1974), shown set, with roof removed. Door (A) is held open by wire trigger. Nest chamber (C) is within the trap. Modified from a figure in Buech (1974).

C. Live trap designed by Rose (1973), shown set. The trap is a Fitch (1950) trap (A; see Fig. 2C) with a large can (B) attached to the rear for a nest chamber. Modified from a figure in Rose (1973).

Rose (1973) added a No. 10 coffee-can to the rear end of a Fitch (1950) trap (Fig. 3C) ; the can acts as a nest chamber so as to greatly increase survivorship.

The traps described so far are capable only of single captures. Burt (1940) designed a wooden trap with a one-way swing trap door to allow multiple captures. It is possible to stock the trap with food, water, and nesting material to increase survivorship. LoBue and Darnell (1958) modified Burt's (1940) design by adding a second chamber (thus two swing doors) (Fig. 4A) ; with this 'double-trap,' the possibility of escape (a problem with Burt's trap) is decreased significantly. It is possible for animals to gnaw out of wooden traps, thus Brown *et al.* (1969) designed a simple multiple-capture trap using plastic pipe and a stainless steel spring door (Fig. 4B). In a comparison of Burt's (1940) trap with the trap of Brown *et al.* (1969), the latter had a higher overall trap success, as well as more multiple captures.

Because of their low weight and small size, soricids are notoriously difficult mammals to catch with any of the traps described so far. Many authors (Brown, 1967; Buckner, 1955; Edwards, 1952; Moore, 1949) have found that pitfall traps are, by far, the most successful traps for shrews. Edwards (1952) found that pitfall traps caught taxa (soricids, zapodids, and some 'rare' microtines) which were rarely, if ever, caught with snap traps. Kale (1972) got similar results when he compared pit traps with Shermans. Boonstra and Krebs (1978) found that pitfalls caught lighter animals than did Longworth traps. Pitfall traps may be used as live traps (Andrzejewski and Rajska, 1972; Boonstra and Krebs, 1978) or, when water is put in the bottom, as kill traps (Buckner, 1955; Edwards, 1952). Pitfalls are also capable of multiple capture whether or not they have water in them (Boonstra and Krebs, 1978). Many items have been used as pitfall traps : No. 10 coffee cans (Brown, 1967), imperial quart oil cans (Buckner, 1955), steel soda cans (Kirkland, pers. comm.), tennis ball cans (Heinemann, pers. comm.), and five pound plastic cottage cheese containers (Yates, pers. comm.). It is possible to obtain lids for the coffee cans and cheese containers; thus traps may be set out permanently and covered when not in use. The soda cans are so small that they must be used with water in the bottom; otherwise, most animals can jump out. The cheese containers, because they can be stacked, are the most convenient to transit. All of these traps are flat-bottomed, and thus sometimes may be difficult to set, especially in rocky or root-filled soil. Robbins (pers. comm.) fashions cone-shaped pitfalls from galvanised steel; these can be set with much less work than any of the flat-bottomed pits require. Galvanised sheet metal drift fences, 6 m long and 20 cm high, may be set radiating out from pitfalls to increase trap success (Riddle, pers. comm.).



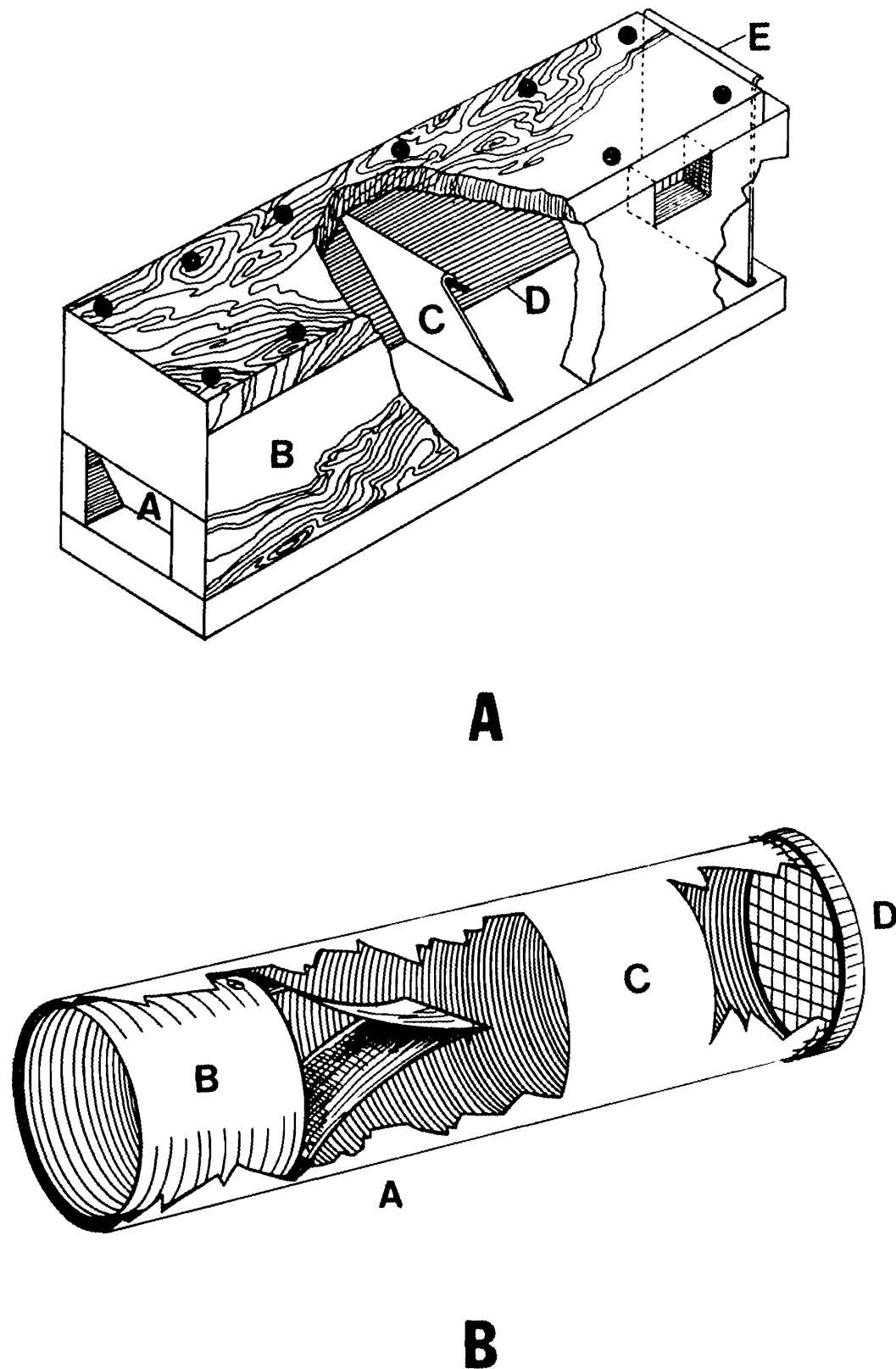


Fig. 4.—A. Multiple-capture trap designed by LoBue and Darnell (1958). Animals push past first door (A) to enter first chamber (B), then past a second door (C) to enter a second chamber (D). The rear wall (E) fits into grooves in the side walls and can be removed to allow the collector access to the second chamber. Modified from a figure in LoBue and Darnell (1958).

B. Multiple-capture trap designed by Brown *et al.* (1969). Animals push past the stainless steel plates (A) which are bent to press lightly against each other. The plates are attached to an aluminium tube (B) which is set into one end of a plastic pipe (C). The mesh (D) at the other end of the pipe is removable. Modified from a figure in Brown *et al.* (1969).

Arboreal species are commonly collected with Victor rat traps nailed to tree trunks. If specimens are needed alive, Shermans, small Hav-a-Harts, or small Tomahawk traps are set in trees. The Hav-a-Hart trap is constructed from heavy-duty large mesh wire, has two sheet metal doors and a floor treadle (Fig. 5A). It is available in many sizes, ranging from  $12 \times 12 \times 43$  cm to  $26 \times 30 \times 100$  cm. When set, either one or both doors can be opened. The Tomahawk is composed entirely of heavy-duty large mesh wire; it has a floor treadle and only one door is open when it is set (Fig. 5B). It is available in sizes comparable to the Hav-a-Hart sizes. In addition, it is foldable, and thus is easy to transport. For maximum trap success in trees, live traps should be set so that they are oriented horizontally (Merritt, pers. comm.) Harrison (1960) designed a simple balance composed of a cement-filled bean-can attached to a long, stiff wire, which is then attached to any box-type live trap (Fig. 6). It can be used to set the trap on a tree limb above the investigator's head and the trap will balance on the limb without the need for attachment. Muul (1968) collected flying squirrels by looking for entrances to nest holes, covering the entrance with a net or plastic bag, and then shaking the tree until the animals exited into the bag. Sonenshine *et al.* (1973) set out nest boxes; once the boxes were occupied by squirrels, they followed Muul's (1968) procedure for capturing the squirrels.

For burrowing animals that come to the surface during the day (*e.g.* ground squirrels), Victor rat traps, Shermans, Tomahawks, or any of the other traps described so far may be set at burrow entrances for capture. Horn and Fitch (1946) designed a surface trap of hardware cloth with a hanging trigger (Fig. 7A). Beer (1959) encircled active burrow entrances with a 25 cm high hardware cloth fence (circumference of 7-8 m); the only opening in this fence was a live trap. Some investigators have used snares for burrowing mammals with much success (Genelly, 1965; Lishak, 1976). Rope is a better snare material than wire because of the high rate of mortality and skin damage associated with the use of wire. Wobeser and Leighton (1979) designed a live trap made of hardware cloth that can be set into the burrow entrance. Several tube live traps have been designed which can be set into excavated burrows. The Gen trap (Shemanchuk and Bergen, 1968) is such a trap and is made of galvanized metal with mesh at one end and a spring door at the other (Fig. 7B). There is no trigger; squirrels simply push their way into the trap past the one-way door. Prychodko's (1952) trap is made of heavy, stiff wire and looks like a giant spring (Fig. 7C). It winds shut at one end; at the other end a tongue of smaller gauge, stiff wire is attached to the trap by a spring. This door can open inward allowing the animal in but not out.

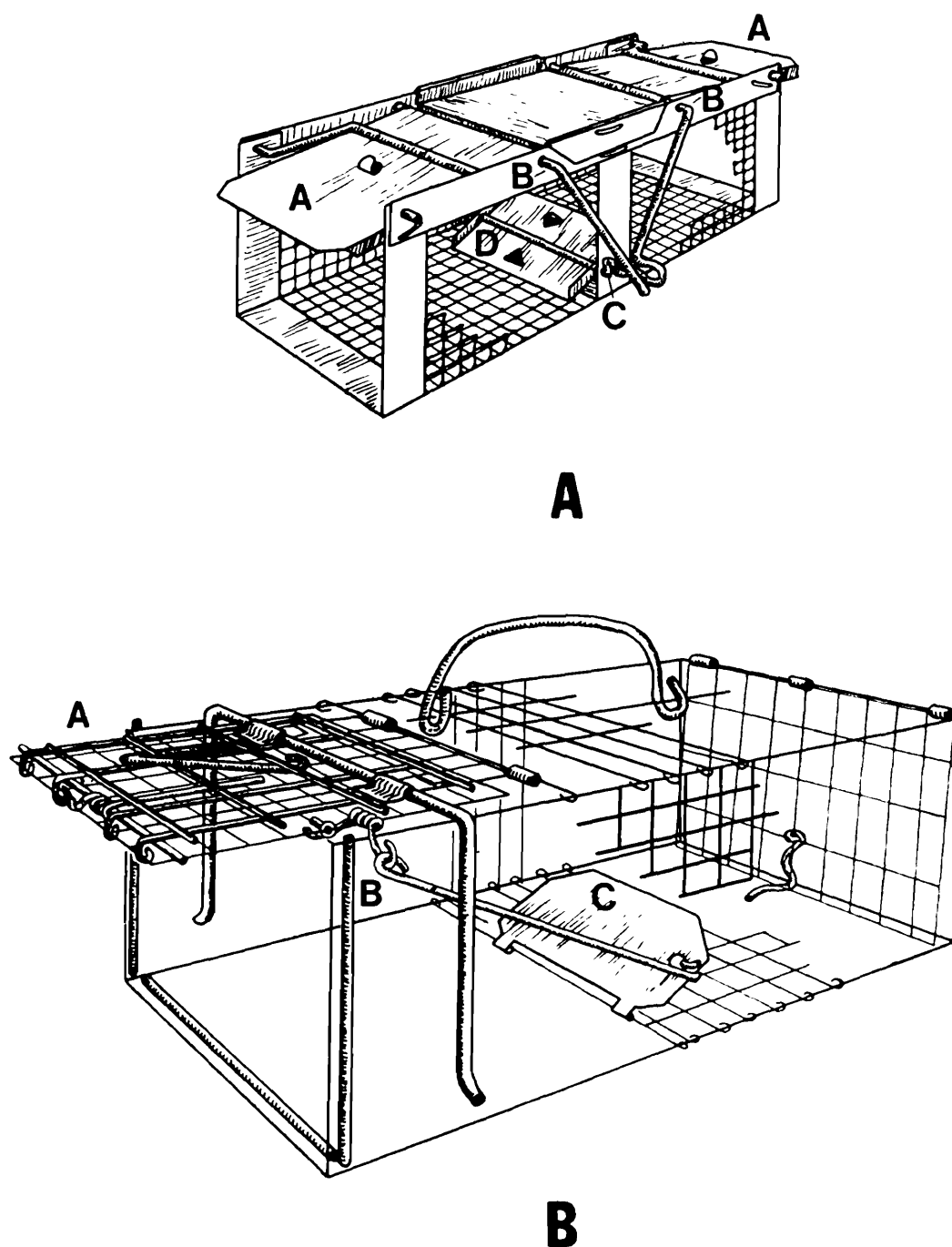


Fig. 5.—A. Hav-a-Hart trap, shown set with both doors open. Aluminium doors (A) are held open with stiff wires (B). These wires are set under trigger (C), which releases when an animal steps on treadle (D).

B. Tomahawk trap, shown set. Door (A) is held open by stiff wire (B) attached to treadle (C).

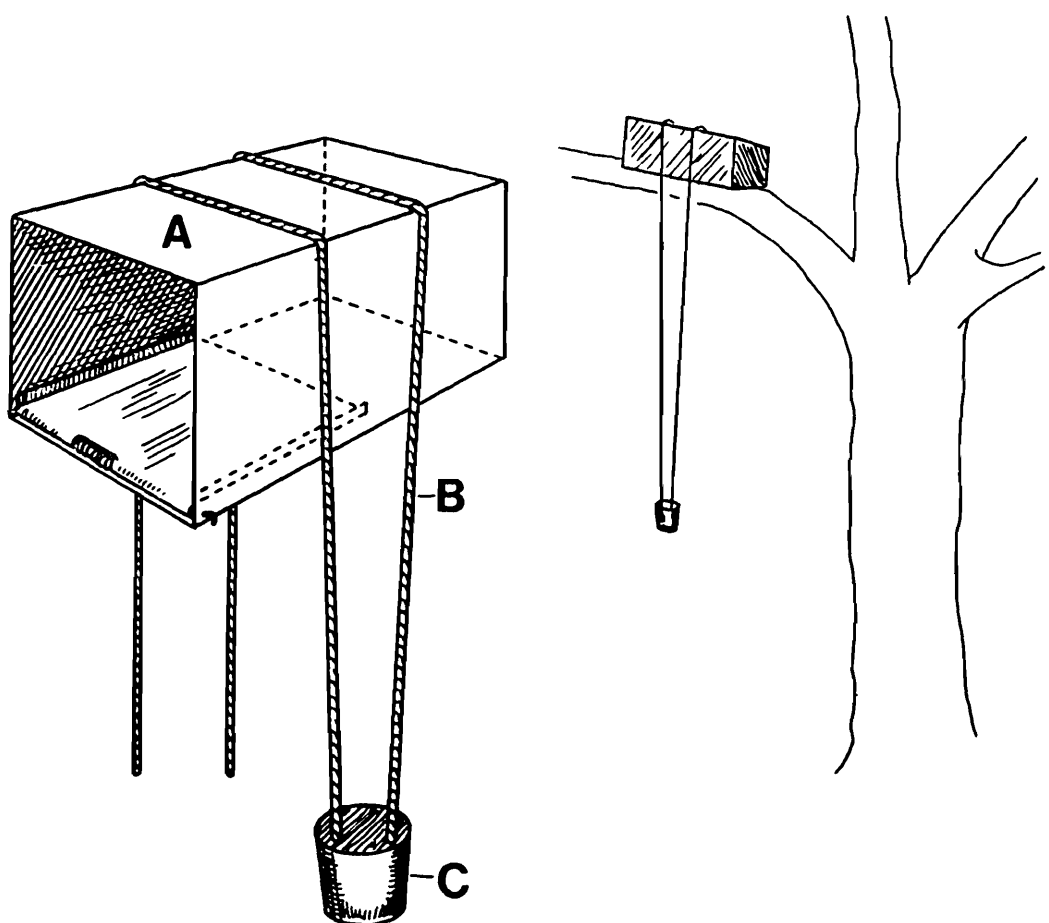


Fig. 6.—Balance designed by Harrison (1960) for setting traps in trees. Trap (A) is soldered to still wires (B) which are bent over the trap. The ends of the wires are put into a cement-filled can (C). The trap can be lifted on to a branch by the can. Modified from a figure in Harrison (1960).

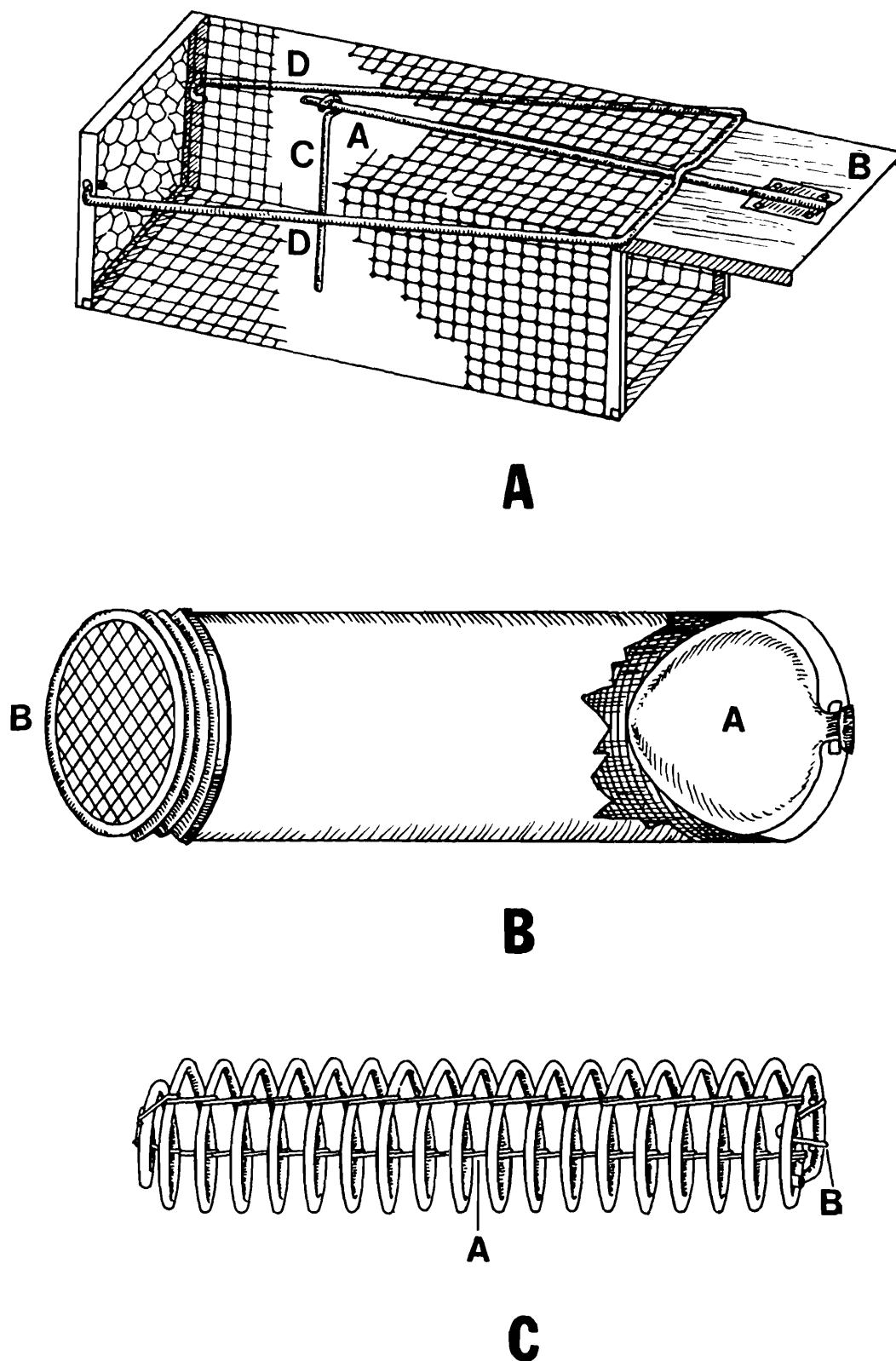


Fig. 7.—A. Squirrel trap designed by Horn and Fitch (1946). Stiff wire (A) is attached to door (B). Door is held open by hanging trigger (C) over wire (B). Wires (D) slip down in front of door as it shuts to hold it in place. Modified from a figure in Horn and Fitch (1946).

B. Gen trap designed by Shemanchuk and Bergen (1968). Concave, metal door (A) is set in one end of a metal tube. The door is one-way. The other end of the tube is covered by removable mesh (B). Modified from a figure in Shemanchuk and Bergen (1968).

C. Squirrel trap designed by Prychodko (1952). Heavy wire is wound into a helix and prevented from straightening by interlacing small wire (A). The helix winds shut at one end; at the other, a tongue of wire (B) is attached so that it can move in, but not out of the trap. Drawing from Prychodko (1952).

Fossorial animals present special problems. Geomyids are collected most commonly with the Macabee trap (Ingles, 1949; Fig. 8A). Macabees are set in excavated burrows; when the animal pushes on the treadle it is caught around the torso by two spikes. It is possible to file down the points on these spikes and use Macabees as live traps with some success. Scheffer (1934) designed a live trap for geomyids using a tube of hardware cloth, blocked at one end. A Museum Special with a trap door attached to the bar is then set in the floor of the tube. The trigger of the Museum Special serves as the trigger of the live trap. Ingles (1949) modified this design by deleting the snap trap and attaching a spring door and trigger directly to the roof of the tube. Sherman (1941) designed a box trap of sheet metal with a hardware cloth floor (Fig. 8B); the treadle and door are similar to that of the Sherman live trap. The trap put together by Baker and Williams (1972) is of plastic pipe (Fig. 8C); a Victor rat trap sits on top of the pipe and serves as the treadle. The trap door is a safety hasp and is attached to the bar of the Museum Special by a wire. All of these live traps are set in excavated burrows.

Talpids, because of their extreme aversion to any opened burrow, are notoriously difficult to collect. The Victor spike trap is most commonly used as a kill trap for moles (Fig. 9). Without any excavation, it is set directly into the ground across an active tunnel. As the animal digs under the trap, it is speared when it hits the treadle. Yates and Schmidly (1975) modified the Victor spike trap by adding a metal box to it. The spike is removed and replaced with a horizontal steel plate. This plate drops down on to the roof and blocks the entrances of the trap when the trigger is hit by the mole. Jensen (1982) designed a trap using similar principles; once set off, the animal is contained within a V-shaped cage of interlocking steel stakes. A collapsible plastic tube with a one-way plastic door has been used with some success for moles, but only if the diameter of the tube is the same as that of the burrow (Yates, pers. comm.). If the diameter is not the same, the moles will avoid the trap. A few species of moles can be collected in pitfall traps, but most species avoid pitfalls.

Trap disturbance by larger animals can be a serious problem for the collector. Brand (1956) solved this problem by setting traps within open-ended rectangular metal boxes. Wires are run through the ends of the boxes at 2.5 cm intervals to keep large animals out, yet allow small mammals to reach the traps. Getz and Batzli (1974) constructed large rectangular boxes of hardware cloth. One end of the box is blocked by wood, the other by mesh wide enough (2.5 cm) to allow small mammals to enter. Live traps are set in the cages with their closed ends to the wood. These protective devices serve to decrease trap disturbance by larger animals, but Getz and Batzli (1974) did not observe any significant effect of the devices on trap success.

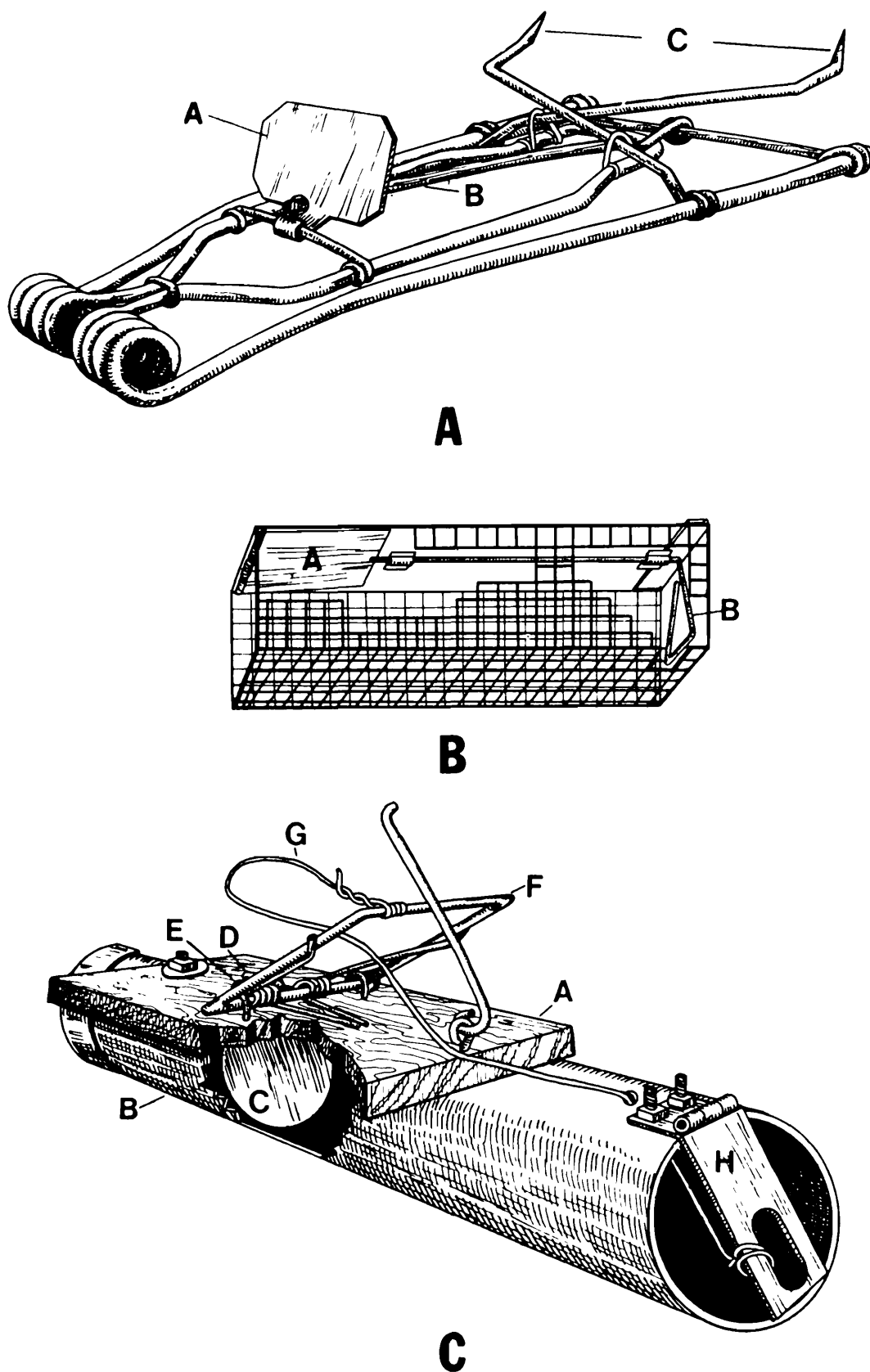


Fig. 8.—A. Macabee trap shown set. Animal hits treadle (A) releasing stiff wire (B), which releases prongs (C) that stab the animal.

B. Gopher trap designed by Sherman (1941), shown set. Door (A) is held open by wire attached to trigger (B). Drawing from Sherman (1941).

C. Gopher trap designed by Baker and Williams (1972), shown set. A rat trap (A) is mounted on a pipe (B). Animal hits the treadle (C), which is attached to trigger (D) through hole (E). When trigger is released, bar (F) flips over, tightening wire (G) and shutting door (H). Drawing from Baker and Williams (1972).

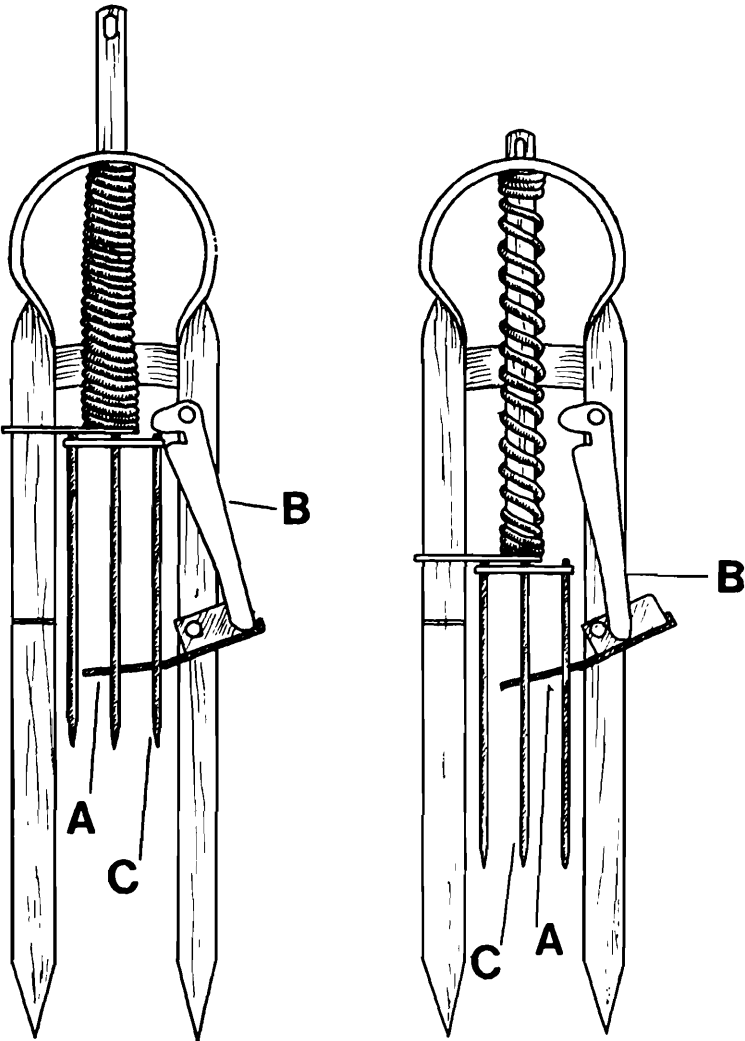


Fig. 9. Victor spike trap shown set (left) and set off (right). Animal hits treadle (A), releasing trigger (B), dropping spike (C).



## TRAPPING TECHNIQUES

Placement of traps is very important to trap success and should depend on the species desired and the habitat to be sampled. For woodland species, it is best to place traps along natural drift fences such as logs or stumps. For grassland species, trap success may be increased by setting in runways or, again, along natural drift fences. Desert species are best collected by setting traps in bare areas between clumps of vegetation or around obvious dens or diggings. Semi-aquatic species can be collected by setting traps at water's edge or on relatively dry hummocks in marshes.

During the winter in areas where the snowfall is heavy, it is still possible to collect small mammals. Many species are active in winter and build elaborate tunnel systems under the snow. It is possible to excavate the snow, and set live or kill traps in active runways found underneath (Fay, 1960; Iverson and Turner, 1969; Merritt and Merritt, 1978; Pruitt, 1959). If the animals are needed alive, it is necessary to stock the traps with ample nesting material for insulation.

Trap stations are, in general, spaced about 10 m apart. As some species are more easily captured with one type of trap than with another, it is often advantageous to set more than one type of trap at each station (Fowle and Edwards, 1954). Traplines should be marked at the beginning and end to prevent loss of traps. It is not necessary to mark each station unless the traps are particularly cryptic (*e. g.* pitfalls), are set in dense vegetation, or have been set in a random fashion (*i.e.* not evenly spaced). Surveyor's tape tied to vegetation near traps is most commonly used as a marker. If traps are to be checked at night, it may be advantageous to use reflective flagging or paint for marking (Lewis, 1967). Riddle (pers. comm.) glues reflective tape to wooden clothes pins, which are then easily clipped to vegetation.

When using snap traps or above-ground live traps, the use of bait significantly increases trap success (Patric, 1970; Stickel, 1948*b*). Bait preferences vary between species, but the most consistently successful bait in use in North America for snap traps is a combination of peanut butter and rolled oats (Beer, 1964; Gottschang, 1965). Microtine rodents tend to prefer raisins (Townsend, 1935), whereas ground squirrels prefer scratch grain (Horn and Fitch, 1946). Plain rolled oats are generally tossed in live traps as bait, as those traps are very difficult to bait with peanut butter. Pitfall traps and traps set underground for fossorial species are generally not baited. Verts (1961) found that carrying the peanut butter-rolled oats bait (with oil added to decrease the viscosity) in a plastic squeeze bottle allowed convenient dispensing. Bait removal by insects can be a serious problem, especially in warm

climates. Getz and Prather (1975) used saturated cotton with peanut butter warmed to 65°C, and then set the cotton on snap trap treadles. Insects were unable to remove the cotton from the traps. Anderson and Ohmart (1977) added dimethyphthalate to a peanut butter-rolled oats bait (1 part dmp : 24 parts bait). The dimethyphthalate repelled insects for up to 20 hours, but did not affect mammal catch success.

Trap success is influenced by many other factors. Rain can significantly increase the capture rate as Mystkowska and Sidorowicz (1961) and Sidorowicz (1960) found in the forests of Poland. In deciduous forest of North America, Gentry *et al.* (1966) and Gentry and Odum (1957) found a higher capture rate on warm, cloudy nights than on cold, clear nights. Trap success is also affected by the season. Some species hibernate, whereas other aestivate (O'Farrell, 1974). Activity patterns should also be considered when setting traps ; some species of small mammals (*e.g.* squirrels) are diurnal, many are nocturnal, and many display a bimodal pattern of activity (*i.e.* they are most active at dusk and just before dawn; Allred and Beck, 1963; O'Farrell and Kaufman, 1975). Food availability can affect trap response ; when more food is available in the habitat, capture rates can decrease significantly (Horn and Fitch, 1946; Smith and Blessing, 1969). At low population densities, trap success will be significantly decreased. Stickel (1960) and Kaufman *et al.* (1974) found that at low densities, animals move farther from their nests than at high densities, thus offsetting some of the effect of low density on trap success.

Many museum collectors are interested in series of animals that include both sexes and all age classes of a species. Trap response of individuals, however, is affected by age and reproductive status. Males of many species are more readily captured than females because they range farther in search of mates (Smith, 1968). Older animals and dominant animals of most species have a higher rate of capture (Andrzejewski and Rajska, 1972; Davis and Emlen, 1956; Gliwicz, 1970; Kikawa, 1964). In comparing the relative success of clean and dirty traps, Hansson (1967) found that most animals were attracted to traps that had been used previously by conspecifics, but avoided traps that had been used by non-similar species. Generally, during breeding season, used traps have far greater success than do clean traps (Boonstra and Krebs, 1976). For some species, young animals prefer clean traps (Summerlin and Wolfe, 1973), whereas for other species, used traps are selected by juveniles (Boonstra and Krebs, 1976).

Experimentation with traps and trapping techniques is recommended to maximise trap success. In addition, factors such as behaviour, ecology, and physiology should be taken into consideration when

preparing to collect small mammals and when evaluating the results of the field-work.

### SUMMARY

Numerous traps and methods of trapping for small mammals have been devised over the years. The trapper must take many factors into consideration when selecting a particular method for use : the type of trap, whether or not the animals are needed alive, the habitat and weather conditions at the trap site, whether or not a particular species is of interest, and what special allowances for behaviour, ecology, physiology, or other factors must be made for that species.

For terrestrial mammals, several snap traps are in common use. There are many live traps ; some are capable of multiple capture, others have nest boxes built in to increase survivorship. Pitfall traps increase the capture rate of animals too small to set off snap or conventional live traps. Pitfalls can be used as live traps, or when filled with water, as kill traps. Arboreal species are generally collected with snap or conventional live traps set in trees. Some fossorial species can be captured with pitfall traps. Special spike traps have been designed to kill fossorial animals in their burrow systems. For live capture, there are several tube-type traps that are set in underground burrow systems.

Trap stations are, in general, well spaced. It is often advantageous to set more than one type of trap at each station to compensate for species-specific trap preference. Traplines should be marked to prevent loss of traps. Trap success is influenced by many factors, including temperature, cloud cover, rainfall, food availability, time of day, season, trap placement, and bait usage. Trappability of various species can be affected by activity cycles, density, sex and/or age of individuals, dominance hierarchies, and trap odor. All these factors should be considered when setting traps and evaluating the results.

### REFERENCES

- ALLRED, D. M. and BECK, D. E. 1963. Range of movement and dispersal of some rodents at the Nevada atomic test site. *J. Mammal.*, **44** : 190-200.
- ANDERSON, B. W. and OHMART, R. D. 1977. Rodent bait additive which repels insects. *J. Mammal.*, **58** : 242.
- ANDRZEJEWSKI, R. and RAJSKA, E. 1972. Trappability of bank voles in pitfalls and live traps. *Acta theriol.*, **17** : 41-56.

- BAKER, R. J. and WILLIAMS, S. 1972. A live trap for gophers. *J. Wildl. Mgmt*, **36** : 1320-1322.
- BEER, J. L. 1959. A method of trapping ground squirrels. *J. Mammal.*, **40** : 445.
- BEER, J. R. 1964. Bait preferences of some small mammals. *J. Mammal.*, **45** : 632-634.
- BOONSTRA, R. and KREBS, C. J. 1976. The effect of odour on trap response in *Microtus townsendii*. *J. Zool.*, **180** : 467-476.
- BOONSTRA, R. and KREBS, C. J. 1978. Pitfall trapping of *Microtus townsendii*. *J. Mammal.*, **59** : 136-148.
- BRAND, R. H. 1956. A protective device for reducing trap disturbance. *J. Mammal.*, **37** : 428-431.
- BROWN, E. B. III, SAATELA, W. R. and SCHMID, W. D. 1969. A compact, lightweight live trap for small mammals. *J. Mammal.*, **50** : 154-155.
- BROWN, L. N. 1967. Ecological distribution of six species of shrews and comparison of sampling methods in the central Rocky Mountains. *J. Mammal.*, **48** : 617-623.
- BUCKNER, C. H. 1955. A simple permanent livetrapp plot for shrews. *J. Mammal.*, **36** : 286.
- BUECH, R. R. 1974. A new live-trap and techniques for winter trapping small mammals. *Can. Fld. Nat.*, **88** : 317-321
- BURT, W. B. 1940. Territorial behaviour and populations of some small mammals in southern Michigan. *Misc. Publs. Mus. Zool. Univ. Mich.*, **45** : 1-58.
- CHITTY, D. H. and KEMPSON, D. A. 1949. Prebaiting small mammals and a new design of live trap. *Ecology*, **30** : 536-542.
- CROWCROFT, P. 1951. Live-trapping British shrews. *J. Mammal.*, **32** : 355-356.
- DAVIS, D. E. and EMLLEN, J. T. 1956. Differential trappability of rats according to size and sex. *J. Wildl. Mgmt*, **20** : 326-327.

- EDWARDS, R. Y. 1952. How efficient are snap-traps in taking small mammals? *J. Mammal.*, **33** : 497-498.
- FAY, F. H. 1960. Technique for trapping small tundra mammals in winter. *J. Mammal.*, **41** : 141-142.
- FITCH, H. S. 1950. A new style live trap for small mammals. *J. Mammal.*, **31** : 364-365.
- FOSTER, C. A. 1945. Techniques in trapping shrews. *J. Mammal.*, **26** : 197.
- FOWLE, C. D. and EDWARDS, R. Y. 1954. The utility of break-back traps in population studies of small mammals. *J. Wildl. Mgmt*, **18** : 503-508.
- GENELLY, R. E. 1965. Ecology of the common mole-rat (*Cryptomys hottentotus*) in Rhodesia. *J. Mammal.*, **46** : 647-665.
- GENTRY, J. B., GOLLEY, F. B. and MCGINNIS, J. T. 1966. Effect of weather on captures of small mammals. *Am. Midl. Nat.*, **75** : 526-530.
- GENTRY, J. B. and ODUM, E. P. 1957. The effect of weather on the winter activity of old-field rodents. *J. Mammal.*, **38** : 72-77.
- GETZ, L. L. and BATZLI, G. O. 1974. A device for preventing disturbance of small mammal live-traps. *J. Mammal.*, **55** : 447-448.
- GETZ, L. L. and PRATHER, M. L. 1975. A method to prevent removal of trap bait by insects. *J. Mammal.*, **56** : 955.
- GLIWICZ, J. 1970. Relation between trappability and age of individuals in a population of the bank vole. *Acta theriol.*, **15** : 15-33.
- GOTTSCHANG, J. L. 1965. Winter populations of small mammals in old fields of southwestern Ohio. *J. Mammal.*, **46** : 44-52.
- GRANT, P. R. 1970. A potential bias in the use of Longworth traps. *J. Mammal.*, **51** : 831-835.
- HANSSON, L. 1967. Index line catches as a basis of populations studies on small mammals. *Oikos*, **18** : 261-276.
- HARRISON, J. L. 1960. A simple trap for squirrels. *J. Mammal.*, **41** : 142-143.

- HOLDENREID, R. 1954. A new live-catch rodent trap and comparison with two other traps. *J. Mammal.*, **35** : 267-268.
- HORN, E. E. and FITCH, H. S. 1946. Trapping the California ground squirrel. *J. Mammal.*, **27** : 220-224.
- HOWARD, W. E. 1953. A trigger mechanism for small-mammal live traps. *J. Mammal.*, **34** : 513-514.
- INGLES, L. G. 1949. An improved live trap for pocket gophers. *Muerrelet*, **30** : 55-56.
- IVERSON, S. L. and TURNER, B. N. 1969. Under-snow shelter for small mammal trapping. *J. Wildl. Mgmt*, **33** : 722-723.
- JENSEN, I. M. 1982. A new live trap for moles. *J. Wildl. Mgmt*, **46** : 249-252.
- KALE, H. W. II. 1972. A high concentration of *Cryptotis parva* in a forest in Florida. *J. Mammal.*, **53** : 216-218.
- KAUFMAN, D. W., FULLER, S. E., O'FARRELL, M. J. and SMITH, M. H. 1974. Trap response in *Peromyscus polionotus*. *Acta theriol.*, **19** : 376-378.
- KIKKAWA, J. 1964. Movement, activity and distribution of the rodents *Clethrionomys glareolus* and *Apodemus sylvaticus* in woodland. *J. Anim. Ecol.*, **33** : 259-299.
- LEWIS, R. E. 1967. A reflecting marker for locating traps at night. *J. Mammal.*, **48** : 146.
- LISHAK, R. S. 1976. A burrow entrance snare for capturing ground squirrels. *J. Wildl. Mgmt*, **40** : 364-365.
- LOBUE, J. P. and DARNELL, R. M. 1958. An improved live trap for small mammals. *J. Mammal.*, **39** : 286-290.
- MERRITT, J. F. and MERRITT, J. M. 1978. Population ecology and energy relationships of *Clethrionomys gapperi* in a Colorado subalpine forest. *J. Mammal.*, **59** : 576-598.
- MOORE, J. C. 1949. Notes on the shrew, *Sorex cinereus*, in the southern Appalachians. *Ecology*, **30** : 234-237.

- MORRIS, R. D. 1968. A comparison of capture success between Sherman and Longworth live traps. *Can. Fld. Nat.*, **82** : 84-88.
- MUUL, I. 1968. Behavioral and physiological influences on the distribution of the flying squirrel, *Glaucomys volans*. *Misc. Publs. Mus. Zool. Univ. Mich.*, **134** : 1-89.
- MYSTKOWSKA, E. T. and SIDOROWICZ, J. 1961. The influence of weather on captures of Micromammalia. II. Insectivora. *Acta theriol.*, **5** : 263-273.
- O'FARRELL, M. J. 1974. Seasonal activity patterns of rodents in a sagebrush community. *J. Mammal.*, **55** : 809-823.
- O'FARRELL, M. J. and KAUFMAN, D. W. 1975. Aspects of activity for *Peromyscus polionotus* using a sand-tracking technique. *J. Mammal.*, **56** : 525-528.
- PATRIC, E. F. 1970. Bait preference of small mammals. *J. Mammal.*, **51** : 179-182.
- PRUITT, W. O., JR. 1959. A method of live-trapping small taiga mammals in winter. *J. Mammal.*, **40** : 139-143.
- PRYCHODKO, W. 1952. A live trap for ground squirrels. *J. Mammal.*, **33** : 497.
- QUAST, J. C. and HOWARD, W. E. 1953. Comparison of catch of two sizes of small-mammal live traps. *J. Mammal.*, **34** : 514-515.
- ROSE, R. K. 1973. A small mammal live trap. *Trans. Kans. Acad. Sci.*, **76** : 14-17.
- SCHEFFER, T. H. 1934. Hints on live trapping. *J. Mammal.*, **15** : 197-202.
- SEALANDER, J. A. and JAMES, D. 1958. Relative efficiency of different small mammal traps. *J. Mammal.*, **39** : 215-223.
- SHEMANCHUK, J. A. and BERGEN, H. J. 1968. The Gen trap, a simple, humane trap for Richardson's ground squirrels, *Citellus richardsoni* (Sabine). *J. Mammal.*, **49** : 553-555.
- SHERMAN, H. B. 1941. A box trap for the capture of live *Geomys*. *J. Mammal.*, **22** : 182-184.

- SIDOROWICZ, J. 1960. Influence of the weather on capture of Micro-mammalia. I. Rodents (Rodentia). *Acta theriol.*, **4** : 139-158.
- SMITH, M. H. 1968. A comparison of different methods of capturing and estimating numbers of mice. *J. Mammal.*, **49** : 455-462.
- SMITH, M. H. and BLESSING, R. W. 1969. Trap response and food availability. *J. Mammal.*, **50** : 368-369.
- SONENSHINE, D. E., CERRETANI, D. G., ENLOW, G. and ELISBERG, B. L. 1973. Improved methods for capturing wild flying squirrels. *J. Wildl. Mgmt*, **37** : 588-590.
- STICKEL, L. F. 1948a. The trap line as a measure of small mammal population. *J. Wildl. Mgmt.*, **12** : 153-161.
- STICKEL, L. F. 1948b. Effect of bait in live trapping *Peromyscus*. *J. Wildl. Mgmt*, **12** : 211-212.
- STICKEL, L. F. 1960. *Peromyscus* ranges at high and low population densities. *J. Mammal.*, **41** : 433-441.
- SUMMERLIN, C. T and WOLFE, J. L. 1973. Social influences on trap response of the cotton rat, *Sigmodon hispidus*. *Ecology*, **54** : 1156-1159.
- TOWNSEND, M. T 1935. Studies on some of the small mammals of central New York. *Roosevelt wild life Ann.*, **4** : 1-120.
- VERTS, B. J. 1961. A convenient method of carrying and dispensing bait. *J. Mammal.*, **42** : 283.
- WIENER, J. G. and SMITH, M. H. 1972. Relative efficiencies of four small mammal traps. *J. Mammal.*, **53** : 868-873.
- WOBESER, G. A. and LEIGHTON, F. A. 1979. A simple burrow entrance live trap for ground squirrels. *J. Wildl. Mgmt*, **43** : 571-572.
- YATES, T L. and SCHMIDLY, D. J. 1975. Karyotype of the eastern mole (*Scalopus aquaticus*), with comments on the karyology of the family Talpidae. *J. Mammal.*, **56** : 902-905.





## COLLECTION METHOD OF BATS

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### INTRODUCTION

Good collection methods ensuring a thorough survey are essential for satisfactory taxonomic and ecological study of a group. Many species of bats, because of their obscure and inaccessible roosts, and nocturnal flying habits, present special difficulties to the collector. This paper deals with various methods used by the author during collection of 24 species and subspecies of bats, mostly in central India and central and western Iraq. A thorough survey also depends upon a good knowledge of habits, and particularly of the habitats, of the animals. Accordingly, notes on the pertinent habits have been provided under each species or subspecies, followed by the method(s) recommended for collecting, given by referring to the serial numbers corresponding to the detail method of collection as given under 'Material and Methods'

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### MATERIAL AND METHODS

**LOCATION OF ROOSTS :** For the diurnal habitat, enquiries to the local people are very necessary as they are at least aware of very large colonies of bats and other large cavities where small colonies may be hiding in holes and crevices, though invisible from outside. During the night, street lights and water holes attract bats for feeding and drinking though it is difficult to collect them at such situations as they generally avoid mist nets (Khajuria, 1979). Fruit bats have been found on fruit trees particularly in guava orchards where they are pests. Presence of faeces may indicate roosts of bat. However, quite often, they show only temporary nocturnal feeding porches where bats rest periodically during foraging activity, mostly to devour the food gathered. A search for faeces is a good method but cannot be used for a thorough survey as the faeces may also fall on places difficult to access, particularly when there is a good vegetational cover. The only good method to ensure a thorough survey

of bats in an area has been described by Khajuria (1976). The bat collectors should move about at dawn and dusk and note the direction of flight in which the bats have disappeared at dawn and from which they are coming out at dusk. If a bat is seen during these hours, it cannot be very far from its roost. A few attempts of waiting every day, watching the direction of the flight will reveal the presence of the roost. As the bats generally live in colonies, large or small, they usually take sufficient time for the entire population of the colony to enter or leave the roost, facilitating their easy location. By using this method, the author was able to collect practically all the species of bats found in Jabalpur district of central India. Besides, this method resulted in the discovery of a new species, and extension of the distributional range of four species of bats. Of course, waiting near human dwellings at dusk and dawn may result in strong protests at least from the lady members of the house, in India.

If the collector is interested in a particular group of bats, one is referred to the classification of bats according to their modes of suspension (Khajuria, 1975c) which gives clues to the nature of their roosts. For instance, the usual roosts of true suspenders (Megadermatidae, Rhinolophidae, Hipposideridae, etc.) are large cavities where bats can suspend themselves by the toes for long periods, while the vespertilionids usually frequent small, narrow cavities where they can rest on all fours, in smaller colonies.

It may, however, be noted that the same species of bat may occupy different habitat types if protection against enemies and weather, and good supply of food and facilities for reproduction are available (*vide* notes under each species and subspecies of bat studied). They also change roosts in search of the above facilities. A few stray individuals may be found in places where they have entered because of bad weather conditions or as a result of mating chases. A few exceptions to the usual roosts may be found. An important exception to the usual roost occupied by a species was found in the case of *Pipistrellus kuhli* in Iraq, where a very large colony occupied shallow cavities on ceilings of seven dark rooms of a ruined monument fully exposed to light. It was a permanent roost. The place was free from human disturbances, and a nearby lake provided good foraging ground.

**COLLECTION METHODS :** After the location of the roosts, the following collection methods have been used by the author :

1. If the cavity had fewer smaller openings, a butterfly net was tied around one of the openings after plugging other exits with cotton wool. While leaving the roost in the evening, the bats flew into the net

(Fig. 1). It is suggested that ordinarily all individuals of the roost should not be collected, at least some of them should be left for further observations.

2. When the roost was inside a narrow and short tunnel, the bats were collected even during the day-time by exhaling cigarette-smoke into the roost till the bats came out. They were then picked up by hand or with a pair of forceps.

3. If the roost was a large cavity, *e.g.*, a cave, with one or a few exits, the bats were collected by tying a mist net or even a fishing net (for fruit bats) so as to block the exits in the afternoon before the bats start coming out of the roost. During the day-time the bats can be disturbed to enter the net, but to avoid unusual disturbances due to which the bats may leave the roost, the evening collection is to be preferred.

4. Setting up of mist nets fishing nets at places where bats have been seen flying, *e.g.*, near water holes, lamp-posts, orchards, etc., has usually resulted in the capture of fruit bats as other species of bats more or less effectively avoid the nets under such situations (Khajuria, 1979). An interesting method of collection of flying foxes by net, for food, fur and as a control measure, has been described by Khajuria (1965). In this

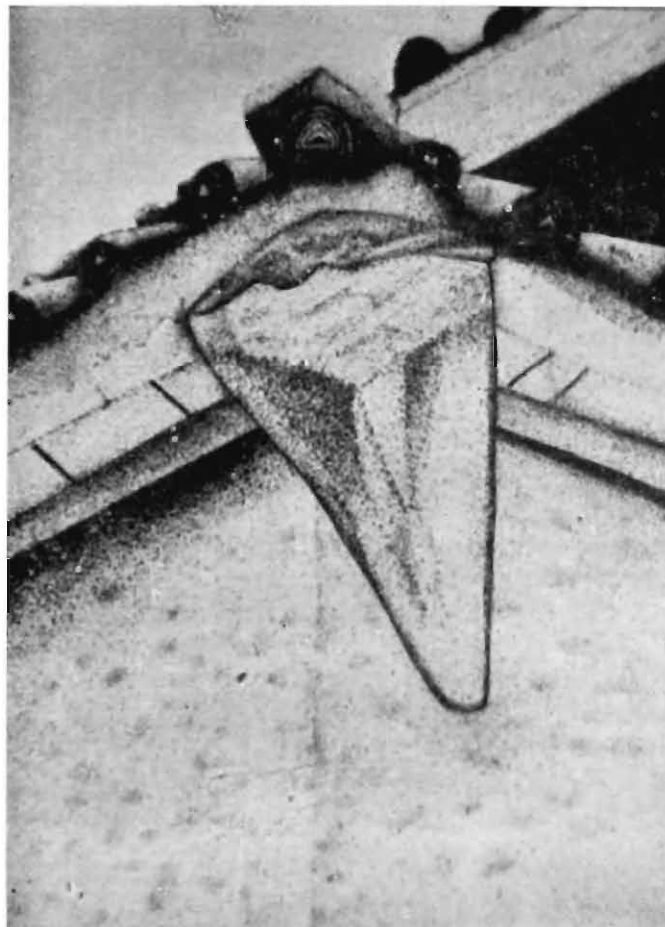


Fig. 1. Bat collection Method No. 1.

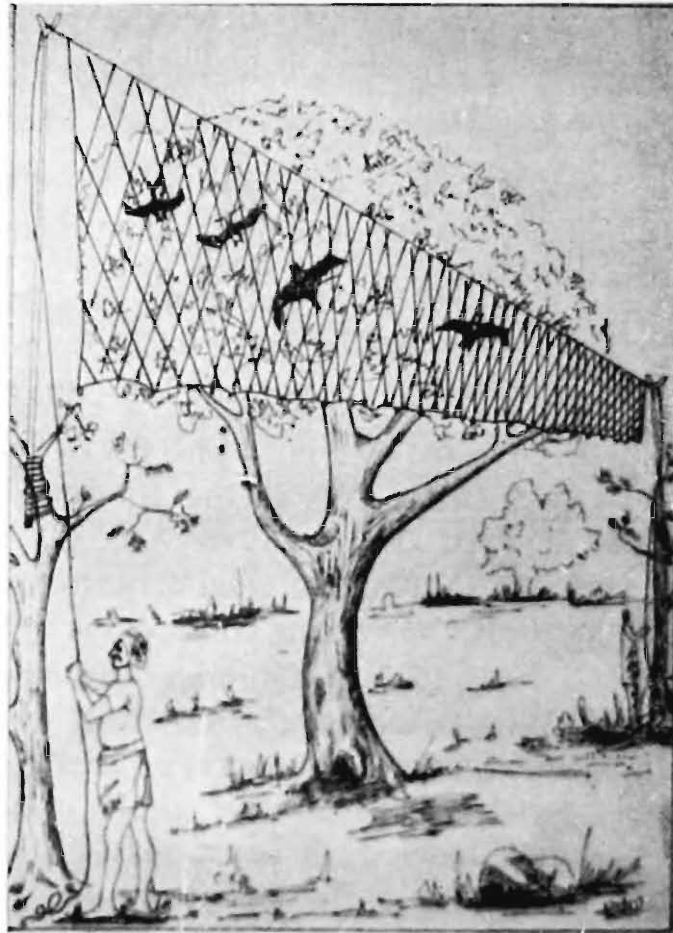


Fig. 2. Bat collection Method No. 4.

method an extensive cotton-twine net of about 30 metres in length and one-and-a-half metre in width, with meshes of about 12 cm sq is set up near the roost (Fig. 2). The net is allowed to slide on a long cotton rope. Small weights in the form of stones, pebbles, etc., are tied to the lower border of the net, at intervals, to keep the net stretched. Each end of the cotton rope from which the net is hung, is passed over a fork tied to a long pole and is held in position by one person. Each of the two poles is tied to the branches of a tree or to some other support as is generally available near the roost, to keep the net at the level of the flight of the bats. If no such support is available the poles have to be sufficiently long to keep the net at the proper height. In the latter case, the poles can be permanently fixed in the ground so as to be available when required. The variations in the levels of flight of individual flying foxes appear to be restricted so as not to necessitate a very wide net. The bats in the roost can be disturbed during the day to enter the net but continuous disturbances may result in abandonment of the roost. A number of nets can be used to cover all directions of flight of the bats.

As soon as one or two flying foxes have been entangled in the net, the latter is lowered by loosening the sliding ends of the rope manually so as to facilitate the removal of the bats immediately. If the bats are

allowed to remain in the net for a longer period, the latter may be damaged by their teeth and violent movements. The net is again put in position for further use, by pulling down the two ends of the rope. In this way the device can be used for a number of times both at dusk and dawn when the flying foxes are in flight which may sometimes be spread over an hour or so.

5. Where the bats can be seen during the day-time and exits are not suitable for the setting up of nets, they can be collected with the help of shot guns using dust shots. If, however, shooting is risky because of the disadvantageous position of the roost or if it is not allowed on religious grounds, nevertheless a few can be collected by throwing pebbles or other missiles. Shooting is also practiced when the bats are flying in large numbers in the open, although the author has failed to bring down a single one so far.

6. If neither a gun nor a net is available and the bats are flying or can be made to fly in large numbers, some of them may be caught by swinging an insect net tied to a pole. A thick thorny bush can also replace the net.

7. Less vigilant bats living in narrower and shorter cavities can be pulled out during the day-time with the help of a pair of long forceps.

8. In very hot weather, some species of bats, particularly the vespertilionids, come out of their narrow roosts and suspend themselves on walls, fully exposed. They can be picked up with a pair of forceps or can be collected with nets.

9. A special type of roost very difficult for a thorough survey, was found near Jabalpur city. It consists of boulders forming a hillock covering about eight acres of land and rising up to a height of about 200 metres. The hillock is surrounded by agricultural lands and is about only one-fourth of a kilometre away from a small railway station. It is well-covered over by earth and overgrown with herbs, shrubs and a few trees, except a portion of about 5,000 square metres in area on the northern face, which presents a bizzare appearance, being a confusion of disorderly huge granite boulders some of which have dimensions reaching up to 40 metres. The spaces among the boulders take the form of countless zigzag caves and crevices of various dimensions ramifying in the interior of the hillock up to a depth of about 50 metres. These caves and crevices, some of which are too narrow for investigation, have several openings through which the bats can leave or enter, thus making their capture very difficult. The temperature, light and humidity vary considerably in different parts of the interior of the hillock. The bats shift to different parts of the caves in different seasons. They were found in deeper

parts in severe winter and summer. Only five species could be collected from here using all the above methods, but apparently more were present.

**PRECAUTIONS :** Although bats have not finally been proved to be the agents for spreading any serious disease to man or to his livestock in India or Iraq, they continue to be good suspects, particularly in the case of rabies and leptospirosis. Immunization of the collector is strongly recommended. In addition to paper masks, it is advisable to use some sort of nasal plugs. Cotton soaked in some harmless antiseptic chemicals such as a weak solution of 'Dettol' or 'Septol' may serve the purpose very well. This will help avoiding the foul smell of the roost as also any viral exhaling of bats particularly when they are being removed alive from nets and there is a possibility of their breath entering the collector's body through his mouth or nostril. While collecting *Pipistrellus kuhli* in Iraq, the author always felt strong congestion in the back of the neck during the removal of live bats from the net with his face close to that of the bat. The congestion was removed after inhaling 'Septol' vapours and applying it in the nasal passages. Khajuria (1975a) has described the habit of urination of several species of Indian bats. Rasweiler (1977) has given a good review of the precautions to be taken while handling bats.

#### NOTES ON THE BATS COLLECTED

The following notes concern habits and habitats of bats pertinent to their methods of collection (indicated by serial numbers corresponding to those given under 'Collection Methods'). The habitat given is either in central India (abbreviated as ('C.I.)) or in central and western Iraq (indicated by the word 'Iraq'). A colony of 50 or less individuals has been regarded as a small colony while a colony of more than 50 individuals has been regarded as a large one.

#### Family PTEROPODIDAE

##### 1 *Rousettus leschenaulti leschenaulti* (Desmarest)

It was occasionally found in ruined temples (large colony) or in temples under worship (small colony), surrounded by custard apple (*Annona squamosa*) and wood apple (*Aegle marmelos*) trees near the Narmada river (C.I.). This bat is sensitive to disturbances and to cold. 3, 4, 5.

A small colony of this fruit bat was also found under a small bridge in Darjiling district, West Bengal.

2. *Pteropus giganteus giganteus* (Brünnich)

It was found on shady tall trees but not on the thorny ones (C.I.). The pregnant females appear to leave the roost for some better place, during parturition. 4, 5.

3. *Cynopterus sphinx gangeticus* Andersen

It was met with in two different habitats in two far off localities, the undersurface of the fronds of palmyra palms and ceiling of a corridor, hanging in small separate clusters. They were not sensitive to noise. 4, 5.

## Family RHINOPOMATIDAE

4. *Rhinopoma hardwickei hardwickei* Gray

It was found in large cavities, either dark or well-lighted (C.I., Iraq). 3, 4.

5. *Rhinopoma microphyllum microphyllum* (Brünnich)

In Iraq, it was met with only at one place, in a large cavity (an artificial cave) near a river. 3, 4.

## Family EMBALLONURIDAE

6. *Taphozous longimanus longimanus* Hardwicke

It is very specific in habitat selection. In and around Jabalpur city (C.I.), large colonies were found under the drooping fronds of palmyra palms. A few smaller colonies each of less than half-a-dozen individuals were found on the ceiling of a corridor. In the adjoining district, it occupied a very peculiar habitat. Here a colony of about 50 individuals was found in an extensive slit (2 m by 4 cm) having a depth of about 13 m, running vertically in the middle of a concrete pillar of a bridge on Narmada river. Most of the bats were well exposed and some of them were only about a metre above the surface of the water. 5.

7. *Taphozous melanopogon melanopogon* Temminck

It was met with in larger cavities (ruined temples and a church) and smaller cavities in between granite boulders in Jabalpur district (C.I.). 3, 5.

8. *Taphozous theobaldi secatus* Thomas

This bat was collected from small boulder caves along with *T. m. melanopogon* from which it is difficult to distinguish in the field. 3, 5.

9. *Taphozous nudiventris kachhensis* Dobson

This bat was found to be a permanent resident of a deep fissure on a rocky hillock near Jabalpur city (C.I.). Some individuals were also



found occasionally on the ceiling of a church and in the well-lighted boulder caves (C.I.). 3, 5.

10. *Taphozous nudiventris magnus* Wettstein

In Iraq, this bat lives in deep rocky fissures. Individuals were also seen in ruined buildings. 3, 5.

Family MEGADERMATIDAE

11. *Megaderma lyra lyra* E. Geoffroy

It is indifferent to the selection of diurnal habitat and has been found in small and large colonies in well-lighted, ruined buildings, soapstone mines, just away from direct sunlight, dark or well-lighted caves and in deserted buildings, etc., but always near a water source (C.I.). 3, 5.

Family RHINOLOPHIDAE

12. *Rhinolophus lepidus lepidus* Blyth

It appears to prefer dark and quiet roosting places, natural or artificial, near water source, and lives in small colonies. 3, 5.

13. *Rhinolophus mehelyi* Matschei

It has been found in small and large colonies in dark sink-holes near water, in Iraq, only during spring and fall.

Family HIPPOSIDERIDAE

14. *Hipposideros lankadiva unitus* Andersen

Dilapidated corridors of a temple under worship near a large tank were inhabited by a large colony (C.I.). 3, 5.

15. *Hipposideros fulvus fulvus* Gray

It was found near Jabalpur city (C.I.) in small or large colonies, in the darker parts of two caves situated on a hillock. 3, 5, 6.

16. *Hipposideros durgadasi* Khajuria

It occurs with *H. f. fulvus* and in a habitat described under serial number 9 ('Collection Methods'). 3, 5, 6, 9.

17. *Asellia tridens tridens* (Geoffroy)

In Iraq, large colonies of this bat inhabit ruined buildings and caves near water. 3, 5.

## Family VESPERTILIONIDAE

18. *Myotis peshwa* Thomas

It was found in small colonies on the under-surface of palmyra palm fronds, in holes of buildings and on the under-surface of a bridge. 1, 3, 5, 6.

19. *Myotis capaccinii* (Bonaparte)

In Iraq, a small permanent colony of this bat was found in an extensive dark sink-hole, with some water at its end. 3.

20. *Pipistrellus coromandra coromandra* Gray

Any dark hole, crevice, or a crack may be inhabited by this species (C.I.). 1, 2.

21. *Pipistrellus mimus mimus* Wroughton

Same as in the previous species.

22. *Scotozous dormeri* Dobson

Same as in the previous species.

23. *Scotophilus kuhli kuhli* Leach

In Jabalpur district (C.I.), large colonies of this bat inhabit drooping fronds of palmyra palms. 5.

24. *Scotophilus heathi heathi* Horsfield

Large holes below the eaves of buildings leading to large spaces between ceilings and tiled roofs are favourite roosting sites of this bat.

## SUMMARY

Methods of collection of 24 species and subspecies of bats belonging to seven families have been discussed. The bats were collected and studied by the author in central India, particularly in the centrally placed district of Jabalpur, and in central and western Iraq. The bats collected are : *Rousettus l. leschenaulti* (Desmarest), *Pteropus g. giganteus* (Brünnich), *Cynopterus sphinx gangeticus* Andersen (Pteropodidae) ; *Rhinopoma m. microphyllum* (Brünnich), *R. h. hardwickei* Gray (Rhinopomatidae) ; *Taphozous m. melanopogon* Temminck, *T. theobaldi secatus* Thomas, *T. nudiventris kachhensis* Dobson, *T. nudiventris magnus* Wettstein (Emballonuridae) ; *Megaderma l. lyra* E. Geoffroy (Megadermatidae) ; *Rhinolophus l. lepidus* Blyth, *Rh. mehelyi* Matschie (Rhinolophidae) ; *Hipposideros lankadiva unitus* Andersen, *H. f. fulvus* Gray, *H. durgadasi* Khajuria, *Asellia t. tridens* (Geoffroy) (Hipposideridae) ; *Myotis peshwa* Thomas, *M. capaccinii* (Bonaparte), *Pipistrellus c. coromandra* (Gray), *P. m. mimus* Wroughton, *P. kuhli* (Kuhl), *Scotozous dormeri* Dobson,

*Scotophilus k. kuhli* Leach and *S. h. heathi* (Horsfield) (Vespertilionidae). A new method effective in thorough survey of bats of a restricted area, developed by the author, is discussed in detail.

#### REFERENCES

- KHAJURIA, H. 1965. A novel method for capture of Indian Flying Fox (*Pteropus g. giganteus* Brünnich) for meat, fur and control. *Cheetal*, **8**(1) : 38-40.
- KHAJURIA, H. 1975a. Urine of bats as means of offence. *J. Bombay nat. Hist. Soc.*, **72** : 194-195.
- KHAJURIA, H. 1975b. A remarkable Tomb Bat. *Cheetal*, **16**(2) : 36-38.
- KHAJURIA, H. 1975c. Methods of suspension, crawling, swimming and defecation in Indian bats with remarks on possible causes of Chiropteran suspension. *J. zool. Soc. India*, **Dr. B. S. Chauhan Comm. Vol** : 99-105.
- KHAJURIA, H. 1976. New methods for collection of bats. *J. Bombay nat. Hist. Soc.*, **71** : 600-601.
- KHAJURIA, H. 1979. Effectiveness of Japanese mist nets in catching Indian bats. *J. zool. Soc. India*, **28** : 152.
- RASWEILER, J. J. 1977. The care and management of bats as laboratory animals. *IN : Biology of bats*, **3** : 519-617. W. A. Wimsatt (ed.). Academic Press, New York and London.

## THE PRESERVATION OF BAT SPECIMENS

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### INTRODUCTION

The proper preservation of bat specimens is an important consideration of all research collections of Recent mammals. In addition to being unique among mammals, bats are often very delicate and require special measures to ensure their care. The proper preservation of bat specimens starts in the field, when the bats are being collected and prepared for the research collection. This paper will discuss these aspects of preservation as they are used by personnel of North American research collections.

### HANDLING

The proper handling of bat specimens can facilitate subsequent preparation. Normally captured bats are kept alive in cloth collecting bags until they are processed. An awareness of problems associated with this method of temporary storage is necessary. If a bag has seams on the inside and the threads of the cloth are fraying, it is possible for a bat to become entangled in the threads, damage membranes, and possibly strangle itself. The body of an unattended dead bat will start decomposing and the membranes will become dessicated. Care should also be taken to avoid similar situations caused by overcrowding specimens in collecting bags. Overcrowding can cause many bats to die because of suffocation and/or overheating. Furthermore, overcrowding of bats may result in "dirty" specimens caused by defecation and urination from other bats. Ideally, only a few specimens of the same species will be maintained in a single bag. These bags should be hung vertically and should be kept in situations that will protect the bats from adverse temperatures, predators, and possible crushing. Greenhall and Paradiso (1968) have commented on a variety of holding cages that may be used instead of cloth bags.

Any sampling technique has bias and, for that reason, it is necessary to become familiar with and implement different approaches to capture

bats. The following summary will provide insight to existing techniques, so that a greater representation of a bat fauna can be obtained.

Prior to the use of Japanese mist nets, acquiring specimens of bats was greatly dependent on locating roost sites. Good sources for roosting are available from Greenhall and Paradiso (1968), Dalquest and Walton (1970), Tuttle (1976), and Kunz (1982), but roosts are generally associated with vegetation such as hollow trees, broadleaf foliage, palm fronds, holes of trees, under loose tree bark, inside rotting snags or tree stumps, inside unfurled banana leaves, and among exposed roots of riparian trees. Buildings may shelter bats under roofs, rafters, eaves, and corrugated metal roofing shingles. Bats may also roost behind tiles and shutters, or inside walls, towers, and elevated floors. Bridge trusses offer sites for some types of bats. Other habitats include mines, sewers, culverts, tunnels, caves, crevices, flat rocks, and fissures. Brosset (1966), Greenhall and Paradiso (1968), and Tuttle and Stevenson (1978) discuss the partitioning of microhabitats within caves in relation to light, temperature, and humidity. Other specific roosts include mammal burrows and arboreal termite nests. A number of neotropical fruit bats will construct roost sites by manipulating palm and *Heliconia* leaves. *Tylonycteris* roost inside the internodal cavities of bamboo.

The collecting of bats in roosting sites include capture by hand, long forceps (or equivalents), hand nets, and special collecting bags on long poles. These and other approaches are discussed by Rosevear (1965), Greenhall and Paradiso (1968), Barbour and Davis (1969), and Tuttle (1976). The use of smoke to force bats from tree hollows can be productive, but the collector must seal other exits and use care to prevent a fire.

Anthony (1931) and Tuttle (1976) discuss the use of firearms to collect bats. The use of a .22-caliber pistol and long rifle dust shot to collect at roosts is recommended. For ranges greater than 4 to 9 m, one can use dust shot in a .32 or .410-caliber auxiliary barrel for larger gauge shotguns. Firearms may also be used for collecting specimens in flight. In this case, it is suggested to shoot the bats over water or an open field for easier retrieval. When collecting bats with firearms, it is also recommended that equipment for care of the specimen be used at the collecting site. This might include small cloth bags, cotton, and absorbants to minimise bleeding and other physical damages to the skin and bones.

In the early 1900's, Lyman (1926) constructed a small net made from material used for insect hand nets, while Jackson (1926) reported that ordinary gill-nets could capture bats. Linen trammel nets from

Italy were found to improve bat collecting and withstand damage in the tropics (Van Tyne, 1933; Sanborn, 1936).

When the Japanese silk mist net was introduced to North American bird banders in 1947 (Greenlaw and Swinebroad, 1967), mammalogists quickly adapted these nets for collecting bats (Dalquest, 1954). These nets proved successful because the fineness of the netting allowed the capture of greater numbers of bats and greater diversity of species, many of which were difficult to acquire by other methods.

Mist nets are now constructed from nylon, monofilament nylon, and terylene. The webbing of nylon or terylene is cut about 20 per cent larger than the frame produced by several horizontal support and vertical end support cords (Bleitz, 1970). The horizontal cords or shelf strings support the loose "pockets" of webbing. Each shelf string terminates with loops of heavy cord, which provide a means of attaching the net to supports (Fig. 1). The most widely used mist nets have four or five "pockets" and are 6, 10, 12, 14, and 20 m wide and 2.3 or 3.3 m high. The webbing preferred for bats is constructed of 38 mm mesh made of 50 denier, 2-ply black nylon thread.

Handley (1968) and Bleitz (1970) provide good accounts for erecting, handling and caring for mist nets. Nets are usually supported at each end by poles. Reasonably straight, uniform, and stiff saplings can also be used. The height of the pole will depend on the height of the net. Metal poles or wooden poles with metal ferrules are convenient for driving the poles into firm ground. Dehaven (1969) presents an example of a telescoping pole arrangement to hoist nets up to 6.7 m. Sections of metal poles with wooden or metal dowels at one end can be stacked by inserting the dowel end of one pole into the open end of another pole. The nets are stretched taut between the poles. The poles are held erect by cords that are tied to stakes, vegetation, rocks, and other stationary objects. The base of the poles can also be supported with rocks or forked sticks in situations where tying is not possible.

Bats that do not detect the net strike it and fall in a "pocket" created from the excess webbing. The bats entangle themselves further in the net when they struggle. Captured bats should be removed as soon as possible in order to prevent damage to both the net and the bat. The tautness of the net should be loose enough so that bats cannot struggle free or bounce off. Holes in the webbing should be repaired to prevent bats from passing through the net.

In the forest habitat conventional mist nets can be hoisted from ground level positions to higher levels for collecting purposes (Greenlaw and Swinebrod, 1967; Handley, 1967; Humphrey *et al.*, 1968; Bleitz,

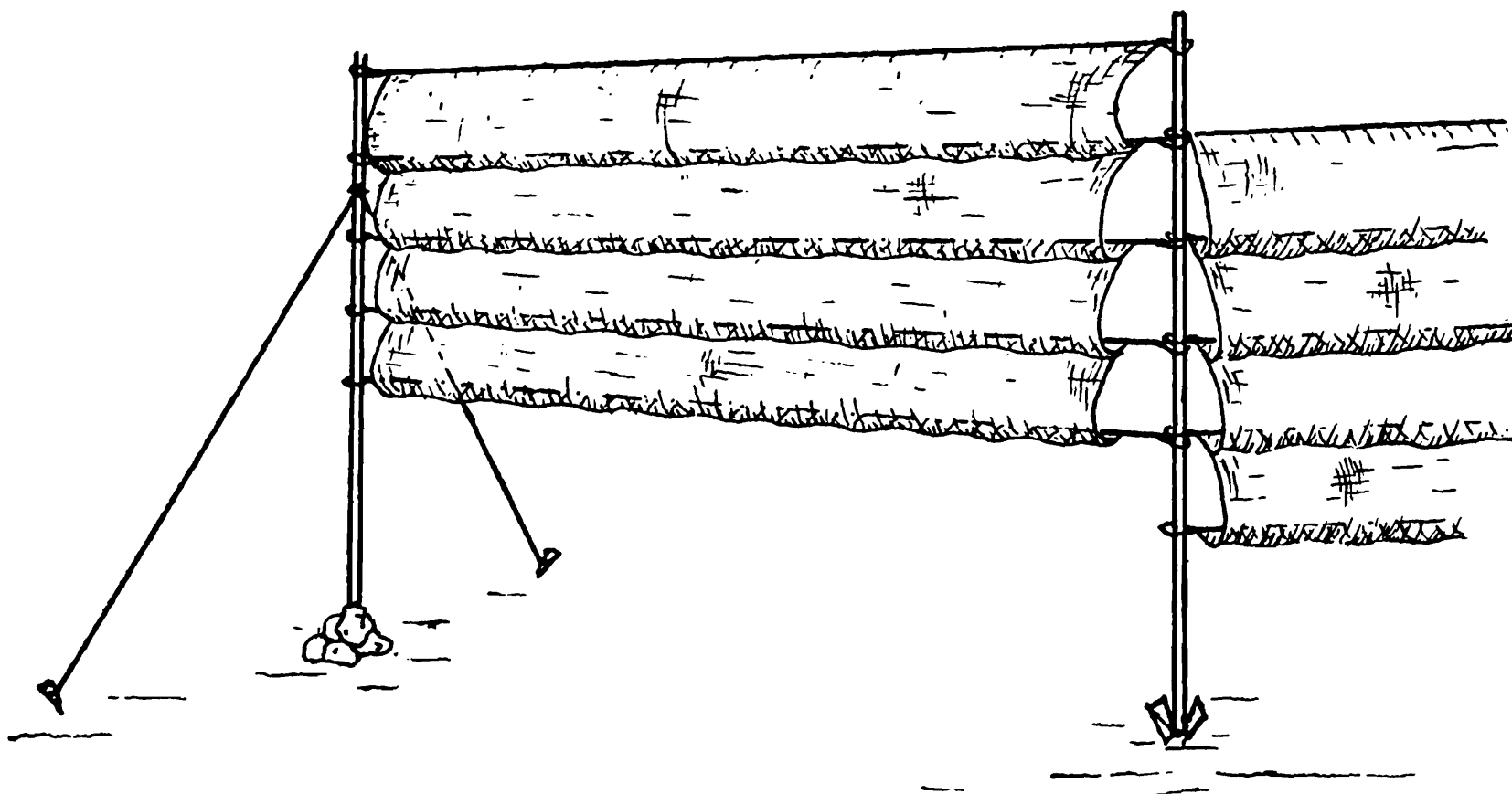


Fig. 1.—Mist nets are set between vertical poles so that the supporting lines are taut, yet spaced to allow the net to sag at each level. It is possible to use a single pole for two nets set in tandem.

1970; Whitaker, 1972). Aerial nets involve the use of support and guy lines that pass over branches, high in the forest canopy, and are tied off or anchored at ground level. An arrangement of nylon net lines strung through pulleys (brass or stainless steel rings) increases the efficiency of lowering the nets to the ground for the retrieval of bats. These elevated

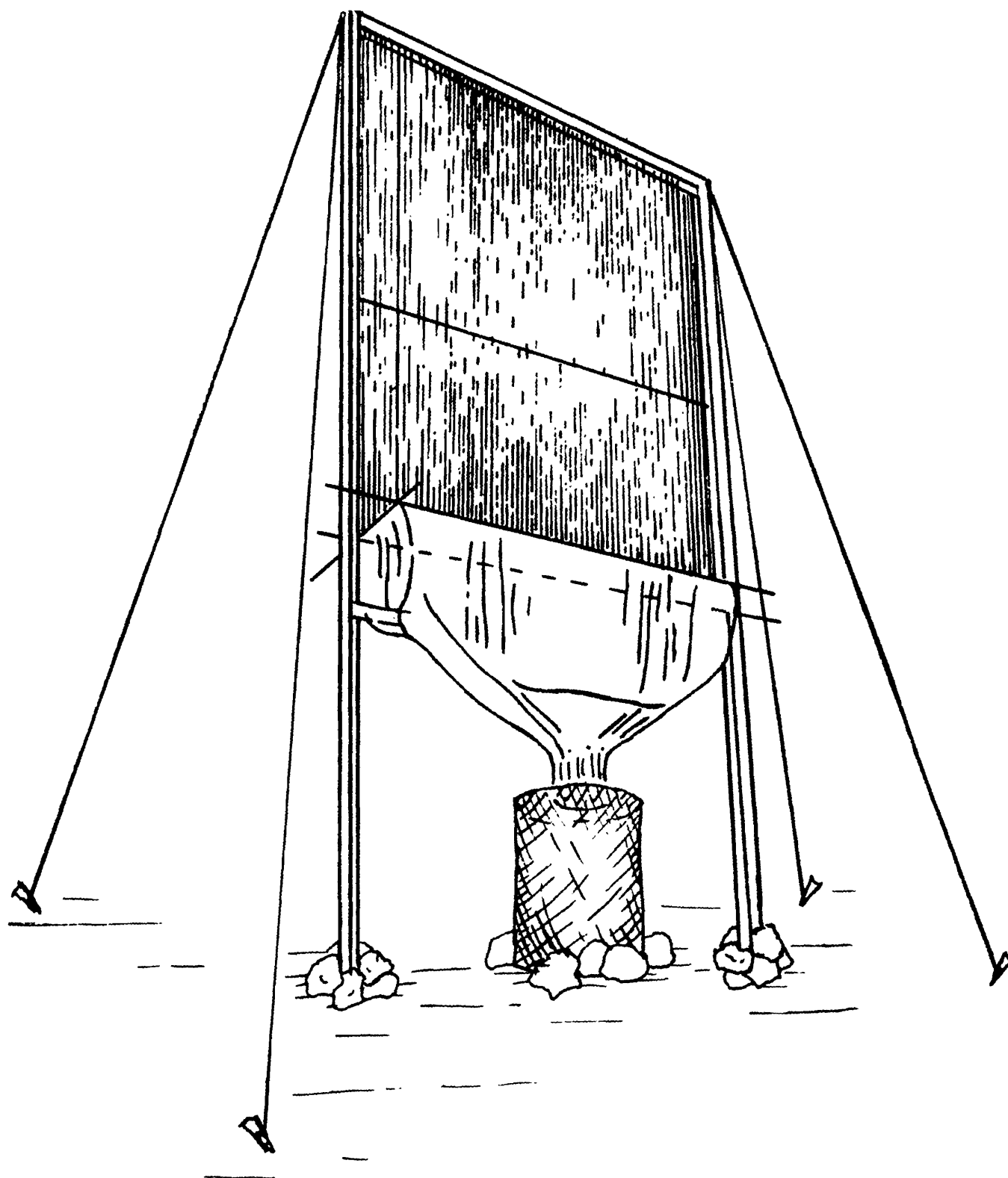


Fig. 2.—The bat trap consists of two parallel frames that support a series of fine vertical wires. Bats fly into the trap and are caught in the space between the two frames. Because the bats can not fly in this space and there is nothing to grab on to, they fall down into a plastic bag that funnels them down into a collecting cage.



nets can also be adapted to non-forest situations. Dejonghe and Cornuet (1983) implemented an aerial net rig at 2460 meters in the northern French Alps for bird migration studies. Bleitz (1970) recommends aerial nets over the face of cliffs.

Constantine (1958, 1967) first devised the 'bat trap' for collecting large series of bats, such as *Tadarida*. The bat trap captures bats as they fly into a grid of parallel wires, slide down along the wires, and fall into a receptacle at the bottom of the framework (Fig. 2). This trap consists of a rectangular aluminium frame (5 m  $\times$  3.3 m) that supports vertical stainless steel wires (0.03 cm). Three one-meter-side lengths compose the single face of strung wire. Each wire is attached to a coil spring on an angle iron fixed to the top of the frame. The tension for each of the three grips of wire is adjusted through a 20 cm turnbuckle, which fastens the bottom angle iron to the frame. A smooth plastic-lined cloth funnels bats down into a collecting cage.

Smaller variations in the bat trap, including a collapsible and more portable version, were used to capture insectivorous bats in open habitat, from roosts in buildings (Constantine, 1958), and from cave entrances (Constantine and Villa-R., 1962 ; Constantine, 1969). Hamilton-Smith (1966) also describes a portable trap made of aluminium tubing and strung with nylon line.

Tuttle (1974a, 1974b) devised and tested an improved Constantine bat trap in an effort to capture the highly manoeuvrable vespertilionids and emballonurids. The Tuttle trap employs two frames (2m by 1.7m) with wires supported by telescoping legs. The tension of all wires is adjusted at the top of each frame. Light monofilament nylon line can be used in place of wire (M. D. Tuttle, pers. comm.). Proper adjustment of the trap frames and wires is essential (Tuttle, 1974b). Tautness of the wires should be proportional to the speed of the bats, adjusted so they are barely tight. When bats escape by bouncing off, wires should be loosened ; when bats pass completely through the trap, wires on both frames should be tightened. Many phyllostomid bats are captured when the spacing between wires on each frame is two centimetres or less (Tuttle, 1974a). Modification of spacing to larger than two centimetres increases the capture of vespertilionids. Spacing the wires of the two frames 7.6 cm seems to reduce the chances of bats passing through the trap. Traps are best suited in narrow passages along streams, trails, and openings to roost sites. The outline of the trap should be camouflaged with vegetation or pieces of foam rubber, so the bats cannot detect the shape of the trap.

Greenhall and Paradiso (1968) summarise a variety of procedures, other than mist nets and traps, for collecting bats from building roosts. These include "trap roosts" (Griffin, 1934), "tunnel nets" (Griffin,

1940), plastic funnel traps (Davis, 1961), and "hopper traps" (Davis *et al.*, 1962). All are designed to capture bats as they roost or as they exit from roost sites.

There are unusual approaches, or accidents, that have captured bats. Borell (1937) and Rausch (1946) have used a fine wire stretched from 2.5 to 3.8 cm over water. When bats fly low to drink, they hit the wire and fall into the water. The bat is retrieved as it swims to the edge of the water. Bats have also been collected in insect light traps (Wilson, 1965); *Antrozous pallidus* have been snap-trapped (Huey, 1936; Killpack and Goates, 1963); *Glossophaga* and *Carollia* were captured in mouse traps baited with banana (Hall and Dalquest, 1963); *Lasionycteris* was captured in a snap trap baited with cheese (Bartzsch, 1956); *Glossophaga*, *Anoura*, and *Lasiurus* were caught in mouse traps hanging over a pile of raw sugar (Goodwin, 1934). Cries of a trapped *Myotis lucifugus* apparently attracted others to enter an open jar, from which they were unable to escape (Hitchcock, 1963). Pine and Duncan (1975) summarised reported impalements of bats on barb wire fences and burdocks, besides an unusual capture on flypaper. Electric cables have been used near fruit trees to electrocute fruit bats (Allen, 1939; Rosevear, 1965). Some bat species can be attracted to the mist nets in response to distress calls from captive conspecifics or from mimic calls produced by the bat collectors themselves or with the aid of mechanical devices.

#### PRESERVATION

The methods used for preserving bat specimens have received considerable attention from many authors (Anderson, 1965; Anon., 1982, undated; Anthony, 1931; Barbour and Davis, 1969; Biswas, 1968; British Museum (Natural History), 1968; DeBlase and Martin, 1981; Hall, 1962; Knudsen, 1966; Nagorsen and Peterson, 1980; Primrose, 1936; Rosevear, 1965; Setzer, 1968; Smithers, 1973*b*; Villa-R., 1966; and Wagstaffe and Fidler, 1968). Specimens of bats are usually preserved as skin and skull, skeletal material only, or in fluid.

Data documentation is one of the most important aspects of specimen preparation. Complete locality records and dates are absolutely necessary. If it is possible to determine the sex of the specimen by external examination, it should be noted and recorded. Standard measurements (total length, length of tail vertebrae, length of hind foot, and length of ear from notch) are taken in millimetres and recorded in the notebook and on the skin tag of the specimen. Total length is taken from the tip of the nose to the last vertebrae, with the specimen lying on its back against the rule. The length of tail vertebrae is taken from the dorsal side of the specimen with the tail positioned perpendicular to the body. The rule is placed at the base of the tail and then used to measure the distance to the last vertebrae. When measuring the total

length of the tail vertebrae, one must be aware that some species have reduced tails enclosed in the uropatagium, resulting in a specimen that appears not to have a tail. Careful examination is always required. The length of the hind foot is usually measured from the heel to the end of the claw of the longest digit. It is recommended to take this measurement by bending the ankle to expose the heel. The length of the ear is usually measured from the notch to the longest point of the pinna.

There are other external measurements that are occasionally taken. For instance, some references (Anderson, 1965; Anthony, 1931) suggest measuring the length of the ear from the crown. The length of the tragus (measured from the base to the tip) is a measurement that may be useful for identification purposes (Anderson, 1965; DeBlase and Martin, 1981; Nagorsen and Peterson, 1980). Anderson (1965) and Wagstaffe and Fidler (1968) suggest illustrating the shape of the tragus on the specimen tag. If possible, accurate weights (in gramme) of the specimens should be recorded. Other measurements such as forearm length are sometimes recommended (Anon., 1982; DeBlase and Martin, 1981; Nagorsen and Peterson, 1980; Rosevear, 1965; Smithers, 1973a) for the sake of field identifications. Wing length and wing breadth have also been described (Anon., 1982). Others (Barbour and Davis, 1969; Nagorsen and Peterson, 1980) have mentioned the use of wingspan. Any measurements other than standard measurements (total length, tail, foot and ear) should be clearly indicated as to what they represent to avoid confusion to other investigators. If a measurement is not taken for some reason, an "X" (not "O") should be used to indicate the omission of that measurement. Some investigators (Anon., 1982; Barbour and Davis, 1969) advocate brief documentation of habitat on the tag. Others (Hall, 1962; Nagorsen and Peterson, 1980; Rosevear, 1965) prefer such information be provided in more detail in the field notes.

The precise methods used for preparing bat specimens will vary from institution to institution, and even from preparator to preparator within the same institution. The primary objectives to keep in mind for any method used are 1) to provide the best long-term preservation for the specimen, and 2) to prepare the specimen in a manner that will expose distinguishing characters and all parts (particularly appendicular osteological parts) for measuring purposes. Both of these objectives can be met with little effort.

### **Skin and Skull Preparations**

The use of water for cleaning a specimen should be held to a minimum (Rosevear, 1965). The specimen should be cleaned and dried with an absorbant of the preparator's choice. The use of various absorbants has been described in the literature. These include hardwood sawdust, cornmeal (Hall, 1962), magnesium carbonate (British Museum

Natural History, 1968), magnesium oxide (Biswas, 1968), sodium fluosilicate (Smithers, 1973*b*), borax (Rosevear, 1965), and others. The authors are aware of problems associated with some of these absorbants and are not prepared at this time to recommend any particular kind.

The skin is next removed from the specimen. This is done by making a midventral incision at the abdomen, being careful not to open the abdominal cavity or sever diagnostic sexual organs. The pelvis is pushed through the opening of the skin, and the tail (if present) and femurs are cut next to the pelvis. This will remove those parts from the carcass, but leave them remaining in the skin. Next, gently slip the skin over the body of the bat until the humeri are exposed. The humeri are cut next to the body and left attached to the skin. The skin is gently slipped over the shoulders, neck, and onto the head. When the base of the ears are exposed they should be carefully cut as close as possible to the skull. After the ears have been disconnected from the skull, carefully slip the skin to the level of the eyes. Extreme care is required to disconnect skin around the eyes from the skull. Damage to cranial parts, such as supraorbital processes (for example, Emballonuridae and Pteropodidae) and zygomatic arches, is to be particularly avoided. The skin around the eye should be removed without cutting the eyelid. Next, the skin is pulled over the rostrum, making it possible to expose the mouth cavity and remove the skin around the lower jaw. The final point of attachment of the skin is at the end of the rostrum. Extreme care is again required to avoid damaging the cranium. Some bats (for example, Rhinolophidae and Hipposideridae) have delicate protruding premaxillary bones and incisors. These bones as well as nasal bones are easily damaged if care is not taken in removing the skin.

When the skin is removed, extraneous tissues should be removed from the skin to facilitate quicker and more even drying. This includes the removal of fat, glands (mammary, facial, pectoral, and anal glands, if present) and muscle tissue from the humeri and femurs. When removing tissues, avoid excessive stretching of the skin. For very large specimens, it may be advisable to remove muscle tissue from the forearm. If this is not done, it may be necessary to inject the muscle tissue with formalin, at a later stage of preparation, to prevent decomposition. It is conceivable that the decision to leave or remove massive muscle tissue from the forearm could have an effect on the forearm measurement after drying, but we do not know of any studies to verify this possibility so that one method could be recommended over the other.

After the skin is carefully removed from the carcass, the skull should be partially cleaned and promptly labelled. DeBlase and Martin (1981) caution against damaging the occipital condyles during this process. The tag with the preparator's initials, field number, and the sex of the

specimen, is strung through the lower jaw, and loosely, but securely, tied, preferably using a square knot (DeBlase and Martin, 1981). Cleaning of the skull usually involves removing the brains, eyes and tongue. The brains may be expelled by gently breaking up the brain tissue and forcing water into the brain cavity with a syringe. Finally, the skull is placed in an appropriate situation for safe drying, that is, safe from loss, mechanical damage, scavengers, insect pests, mildew, and masceration.

After extraneous tissues have been removed from the skin, the specimen may be stuffed. While the skin is inverted, it is easy to close the mouth and other tears or cuts (if present) by sewing. The mouth may be closed by stitching the lower lip to the two sides of the upper lip (Anthony, 1931; Hall, 1962; Nagorsen and Peterson, 1980; Setzer, 1968), or in the case of very small bats, joining the lips together with a single stitch (Barbour and Davis, 1969). The skin can then be turned so that the hair is on the outside. The wings, back legs, and tail should be gently pulled to insure they are properly positioned. Next, a loosely folded piece of cotton, that approximates the size of the carcass of the specimen, is secured with forceps or hemostats. While holding the cotton with either instrument, the specimen is opened at the incision and slipped over the cotton body. It is also possible to insert the cotton by pushing an inverted skin over the cotton as described by some authors (Hall, 1962; Nagorsen and Peterson, 1980). Some preparators may find the latter method a little more difficult for bat specimens because of the wings. Once the cotton is in the specimen, the skin can be positioned while the cotton is still being held with the forceps or hemostats. After positioning is completed, the cotton is released and any excess is removed. The remainder of the cotton is neatly tucked into the skin. The preparator should avoid grossly understuffing or overstuffing bat specimens (Rosevear, 1965). Overstuffing is very easy to do because the dorsal and ventral sides of the wing membranes can easily separate to accommodate excessive cotton. Over-stuffed specimens typically appear to have bare sides between the shoulders and back legs.

Before the incision of a specimen is sewn closed, it may be necessary to add wire to the back legs and tail (if present) for support. This will depend on how the specimens have been prepared and the characteristics of the species. For those specimens that have most of the leg bones remaining in the skin and have an interfemoral membrane, it may not be necessary to put wires in the legs because the bone and dried membranes will provide adequate support (Hall, 1962). If the leg bones have been removed, or the interfemoral membrane is greatly reduced, it may be advisable to provide additional support with monel wire (any metal that is subject to corrosion should not be used). If the tail is present it can be treated in a similar manner—that is, allow the tail vertebrae to provide the necessary support. However, for some groups of bats (for

example, Vespertilionidae, Nycteridae, and Natalidae) a wire used with, or replacing, the tail vertebrae can be useful in properly positioning the interfemoral membrane. For some other types of bats, it may be desirable to sue a wire to help expose the extent, or position of, the tail (for example, Emballonuridae). The decision to use wire in preparing bat specimens ultimately depends on the support and positioning required by the individual specimen.

Finally, the midventral incision is closed by sewing. Next, the specimen tag should be attached. Any final examination, such as verifying sex and obtaining reproductive condition (DeBlase and Martin, 1981; Smithers, 1973a) by dissection, should be conducted and appropriate data added to the tag. The tag is then secured to the right leg of the specimen. It is recommended that the tag be passed through the membranes on the dorsal side at a location below the right knee (DeBlase and Martin, 1981; Hall, 1962), using fine-pointed forceps or a large needle. This will allow secure attachment of the tag to the skin, which is not necessarily guaranteed if the tag is tied at the ankle. Also, use of the latter method can interfere with pinning the specimen as well as obscure identifying characters (for example, keeled calcar and position of membrane attachment to the foot) of the bat (DeBlase and Martin, 1981). Tags should be securely tied, using a square knot. The string attaching the tag to the specimen should not be so short as to interfere with the positioning of the tag or potentially damage the specimen; also it should not be so long that the string gets tangled. For most situations, a length of 2.5 cm is a suitable distance between the tag and specimen.

At this stage of skin preparation of bats, it must be realised that the positioning and pinning of a specimen will determine its usefulness for research purposes, the likelihood of it being subjected to physical damage or causing damage to other specimens in storage, and the appearance of the preparation. No matter how well, or how poorly, a specimen is prepared up to this point, the pinning and positioning will influence the quality of the specimen. When positioning and pinning bat specimens for drying, there are a few important points to remember for easier identification and examination in the future (Fig. 3) : (1) The distal and proximal portions of the forearm should be exposed so that they may be measured. This primarily involves tucking the wing membranes under the proximal end of the forearm. (2) All of the metacarpals and phalanges should be exposed so that they may be measured and compared to one another (Anderson, 1965; Hall, 1962; Nagorsen and Peterson, 1980). A slight bend at the joints may facilitate measuring these bones. (3) The attachment of the wing membrane to the hindfoot should be evident. (4) The calcar should be exposed to show its length and whether or not it is keeled. There are two points to remember to provide protection to the specimen as well as surrounding specimens. (1) Bat speci-

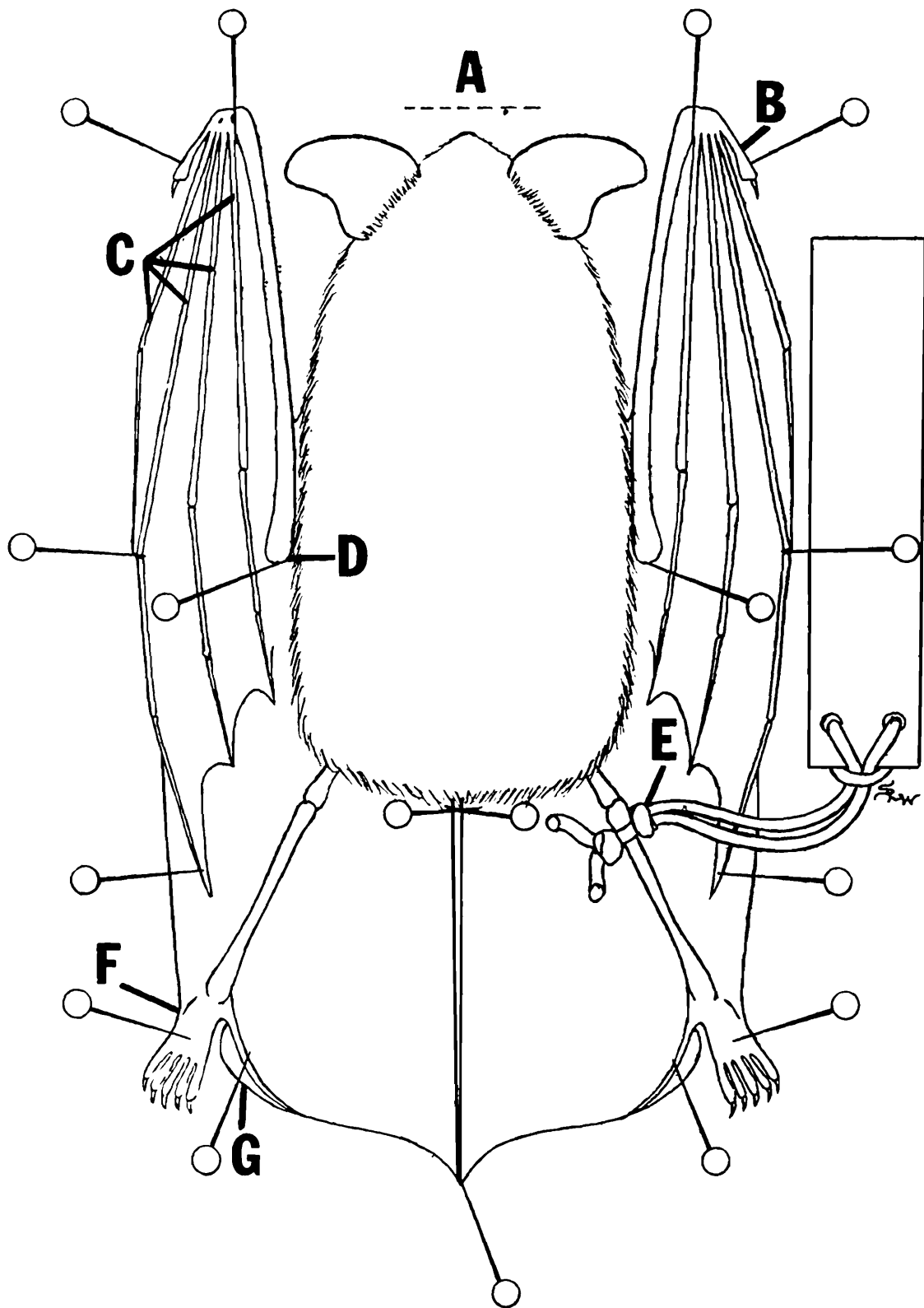


Fig. 3.—Skins of bat specimens should be positioned and pinned in a manner that will provide protection and expose distinguishing characters and appendicular parts for measuring purposes. A. The wings of the specimen should be positioned far enough forward to protect delicate facial characters during storage. B. The thumb of the specimen should be turned down so that it is not broken, or catch and damage other specimens. C. The metacarpals and phalanges should be exposed for measuring purposes and comparing with one another. D. The membrane at the elbow should be pinned down to expose the proximal end of the forearm for measuring purposes. E. The specimen tag should be tied on the dorsal side, below the right knee, to ensure the tag does not slip off the specimen. F. The location where the wing membrane attaches to the leg should be exposed for purposes of identification. G. The presence (or absence) of a keeled calcar should be evident for purposes of identification.

mens should never be positioned with either wing extended. This practice serves no practical purpose. Such specimens require four to six times the storage space normally required and the wings are very likely to receive physical damages such as torn membranes and broken bones (Anderson, 1965; Knudsen, 1966; Wagstaffe and Fidler, 1968). Furthermore, measurements of the forearm cannot be taken in the same manner as those specimens with folded wings, thus causing another variable in data documentation. (2) The thumb of the bat should always be turned down and pinned beside the next digit (Anthony, 1931; Hall, 1962). If left extended it is subject to breakage or catching and tearing other bat specimens. Finally, an effort should be made to make symmetrical specimens that can easily be stored in standard storage situations.

The pinning of the specimen starts by placing the bat ventral side down and placing a pin in each wing near the wrist. These pins should be spaced slightly wider than the body and should be equidistant from, and form a line perpendicular to, the long axis of the specimen. Next, the forearms are aligned more or less parallel to the long axis of body, perhaps converging slightly at the proximal ends. A pin is placed at each elbow so that the proximal end of the forearm is exposed. The position of the feet will determine the position of the body. Normally, the anterior portion of the body is slightly behind the distal portion of the forearm. This will help protect delicate facial characters from physical damage during storage. The feet are next positioned about the same distance apart as the wrists so that the uropatagium can be adequately displayed. The feet, pinned ventral side down, should be equidistant from, and form a line perpendicular to, the long axis of the body. If a tail is present, the base is pinned down along the midline, the tail is extended, and the tip is pinned down along the midline. For specimens with, or without, tails, each calcar is gently extended to display the margin of the uropatagium. Care is required to pin the calcar in a manner that will show the presence of a keel. Next, the wings are positioned and pinned. Some preparators will position the wings so that the digits form wide arcs. However, extreme cases of this method result in more space-consuming, saucer-shaped, specimens that tend to turn easily in collection storage trays. When positioning the digits, one may find a pair of forceps very useful. The first digit of each wing is positioned more or less parallel to the long axis of the body, and pinned near the tip. The remaining digits should be positioned so that they are not hidden among the membranes of the wing. It may be convenient and necessary to pin the tips of the remaining digits to properly expose all of the metacarpals and phalanges. Finally, the thumbs are turned down and pinned next to the first digit. A final inspection may require minor positioning and pinning of the specimen to ensure symmetry or exposure of important characters (Hall, 1962). If a nose-leaf is present, a pin should be positioned to hold it in an erect position.



With the specimen pinned, the next consideration is drying. If the specimen is large and has excessive muscle tissue remaining on the forearm, drying the wing may be slow. It may be necessary to inject the tissues with formalin to ensure preservation and facilitate drying. The membranes, ears, and nose-leafs (if present) are among the more difficult parts to dry. Exposure to sunlight is never recommended because uneven drying and color changes may occur. Good air circulation is the best solution. Often the ears and nose features are deformed because of improper drying. Methods used to minimise this problem have included propping the parts in position. At the Thailand Institute of Scientific and Technological Research in Bangkok, a piece of masking tape has proved useful in drying the ears in an extended position. Although the method does have merit, it is not known what the masking tape does to the surface tissue of the specimen. Anderson (1965) discusses the use of shellac on the inside of the ear and 'pinching and positioning the ear as it dries. Once the specimen is completely dry, the pins are carefully removed by holding the specimen securely as each pin is extracted.

### **Skeletal Preparations**

Preparation of full skeletons can provide a research collection with valuable comparative osteological material as well as being particularly useful for paleontological and anthropological studies. Such preparations have been described in detail in the literature (DeBlase and Martin, 1981; Lucas, 1950) and involve eviscerating the specimen and removing the skin and excess muscle tissue from the bones to facilitate drying. Nagorsen and Peterson (1980) describe the removal of the membranes from the appendages. Care is required to avoid damaging or losing small skeletal parts, such as clavicles, hyoid bones, and bacula (DeBlase and Martin, 1981; Hall, 1962). After the skeleton has been cleaned sufficiently, it should be neatly folded and wrapped with thread or string (Anthony, 1931; Hall, 1962; Lucas, 1950). This procedure will help save space and will help prevent bones from being broken. For large specimens, it may be necessary to remove the skull so that the brains may be removed (see Skin and Skull Preparations). The skull is labelled with a skull tag as previously described. If the skull is detached, a similar tag is also required for the postcranial skeleton. These tags will serve as references to additional data documented in the field catalogue and field notes.

### **Fluid Preparations**

Standard preservation procedures of bats should always include fluid-preserved material. Such preparations are ideal for maintaining

diagnostic features of the mouth, nose, and ears. Furthermore, such specimens allow external and internal examination that would be suitable for a variety of research applications. If the skull is needed for examination, it can be extracted through the mouth opening of the skin. Because the cranial sutures of bats are completely fused, the deleterious effects of fixatives and preservatives to connective tissues of bone are minimal. Methods of cleaning skeletal material extracted from fluid-preserved specimens have been described in the literature (Case, 1959; de la Torre, 1951).

Generally data documentation for fluid-preserved specimens is restricted to the use of the field catalogue. A tag of high quality paper (resistant to deterioration by fluids) is tied through the membranes and around the right leg below the knee on the dorsal side, using a square knot (DeBlase and Martin, 1981 ; Hall, 1962). The preparator's initials and preparation number and sex of the specimen are written in permanent black ink on the tag. Other data and documentation concerning the specimen is placed in the field catalogue.

For most fluid preparations, a one-to-nine ratio of 37-40% commercial formaldehyde to water is used to prepare a formalin fixative (Barbour and Davis, 1969; Biswas, 1968; Hall, 1962; Nagorsen and Peterson, 1980). Because formalin is acidic, it is recommended that it be buffered if possible. Phillips (1988) discusses the use and benefits of buffers and other fixatives. Specimens should be fixed as soon after death as possible. For purposes of identification, it is often convenient to prop the mouth open to allow examination of the teeth. Generally, the preservation process involves injecting sufficient amounts of fixative into the abdominal and thoracic cavities and into the larger muscles. A hypodermic needle attached to a squirt bottle is an ideal apparatus for injecting large series of specimens. Sometimes an incision is made into the body cavity to allow free entry of the fixative into the body (Barbour and Davis, 1969; Biswas, 1968; Nagorsen and Peterson, 1980). The body with the attached specimen label is placed in the fixative. Over crowding of specimens in fluid is to be avoided to ensure proper preservation as well as prevent physical damage to the specimens (Levi, 1966). The amount of fixative used should be ten times the volume of the specimen (Biswas, 1968).

The specimens should remain submerged in fixative for at least 12 hours (Nagorsen and Peterson, 1980) to four days (Quay, 1974). Storage for extended periods of time in standard formalin solutions should be avoided, because decalcification of the bone and teeth can occur (Quay, 1974; Nagorsen and Peterson, 1980). Nagorsen and Peterson (1980) suggest storage in fixative for less than two months will not create serious problems with preservation. After the specimens have remained in

fixative for a sufficient amount of time, they should be washed in clean water to remove the fixative, and then transferred to a preservative. Either 70 % ethyl alcohol or 45 % isopropyl alcohol are commonly used preservatives (Levi, 1966; Nagorsen and Peterson, 1980; Quay, 1974). The use of isopropyl alcohol is less desirable because it causes the specimen to be brittle (Anon., 1982). Phillips (1988) discusses the use of various preservatives.

### CONCLUSION

The preservation of bat specimens begins with proper care and handling of the specimens when they are collected. The primary considerations in preparing specimens are providing the best long-term preservation method possible and preparing the specimen in a manner that will be the most useful for research purposes.

### SUMMARY

The proper preservation of bat specimens is an important consideration of all research collections of Recent mammals. Bats are often delicate and require special measures to ensure their care and usefulness. The proper preservation of bat specimens starts in the field when the bats are being collected and prepared for the research collection.

The proper handling of bat specimens can facilitate subsequent preparation. There are various methods and techniques of maintaining them until they are prepared.

Details are given about preserving bats as a skin and skull, skeleton only, and in fluid. The primary objectives in preparing specimens are (1) providing the best long-term preservation method possible and (2) preparing the specimen in a manner that will be the most useful for research purposes. Recommendations that support these objectives are provided.

### REFERENCES

- ALLEN, G. M. 1939. *Bats* : x+1-368, Harvard University Press, Cambridge.
- ANDERSON, R. M. 1965. Methods of collecting and preserving vertebrate animals. *Bull. natn. Mus. Can.*, 69 (Biol. Ser. 18) : vii+1-199.

- ANONYMOUS. 1982. *Bats. Data, measurements and preservation* : 1-7. Trustees Natn. Mus. Monm. Zimbabwe, Causeway.
- ANONYMOUS. Undated. *Bats and rodents. Data and measurements. The pinning of study skins* : 1-7. Natn. Mus. Rhodesia, Causeway.
- ANTHONY, H. E. 1931. The capture and preservation of small mammals for study. *Guide Leaf. Am. Mus. nat. Hist.*, **61** : 1-54.
- BARBOUR, R. W. and DAVIS, W. H. 1969. *Bats of America* : 1-286. Univ. Press Kentucky, Lexington.
- BARTZSCH, P. 1959. An interesting catch. *J. Mammal.*, **37** : 111.
- BISWAS, B. 1968. Mammals. Their collection and preservation for study. Pp. 139-152. IN : *A handbook for zoological collectors*, (ed) A. P. Kapur : v+1-152. Zoological Survey of India, Calcutta.
- BLEITZ, D. 1970. Mist nets and their use. *Inland Bird Banding News*, **42** : 43-52.
- BORELL, A. E. 1937. A new method of collecting bats. *J. Mammal.*, **18** : 478-480.
- BRITISH MUSEUM (NATURAL HISTORY). 1968. *Instructions for collectors. No. 1. Mammals (non-marine)*. Trustees British Mus. (Nat. Hist.), 665 : v+1-55.
- BROSSET, A. 1966. *La Biologie des Chiropteres* : 1-237, Masson, Paris.
- CASE, L. D. 1959. Preparing mummified specimens for cleaning by dermestid beetles. *J. Mammal.*, **40** : 620.
- CONSTANTINE, D. G. 1958. An automatic bat-collecting device. *J. Wildl. Mgmt*, **22** : 17-22.
- CONSTANTINE, D. G. 1967. Activity patterns of the Mexican free-tailed bat. *Univ. New Mex. Publs. Biol.*, **7** : 1-79.
- CONSTANTINE, D. G. 1969. Trampa portatil para vampiros usada en programas de campanna antirabica. *Boln sanit., Panam.*, **67** : 39-42.
- CONSTANTINE, D. G. and VILLA-R, B. 1962. Metodos de lucha contra los vampiros transmisores de la rabia. *Boln. sanit., Panam.*, **53** : 7-12.

- DALQUEST, W. W. 1954. Netting bats in tropical Mexico. *Trans. Kans. Acad. Sci.*, **57** : 1-10.
- DALQUEST, W. W. and WALTON, D. W. 1970. Diurnal retreats of bats. pp. 162-187. IN : *About bats*. SLAUGHTER, B. H. and WALTON, D. W. (eds) 11 : vii+1-339. Southern Methodist University Press, Dallas.
- DAVIS, R., HERREID, C. and SHORT, H. 1962. Mexican free-tailed bats in Texas. *Ecol. Monogr.*, **32** : 311-346.
- DAVIS, W. H. 1961 Tips on techniques. *Bat Banding News*, **2** : 26-28.
- DeBLASE, A. F. and MARTIN, R. E. 1981 *A manual of mammalogy with keys to families of the World* : xii+1-436. W. C. Brown Co. Publ., Dubuque, Iowa.
- DeHAVEN, R. W. 1969. Telescoping mist-net poles. *Inld. Bird Banding News*, **41** : 84-85.
- DeJONGHE, J. F. and CORNUET, J. F. 1983. A system of easily manipulated, elevated mist nets. *J. Fld. Orn.*, **54** : 84-88.
- GOODWIN, G. G. 1934. Mammals collected by A. W. Anthony in Guatemala, 1924-1928. *Bull. Am. Mus. nat. Hist.*, **68** : 1-60.
- GREENHALL, A. M. and PARADISO, J. L. 1968. Bats and bat banding. *Resour. Publs Bur. Sport Fish and Wildl.*, **72** : 1-48.
- GREENLAW, J. S. and SWINEBROAD, J. 1967. A method for constructing and erecting aerial-nets in a forest. *Bird-Banding*, **38** : 114-119.
- GRIFFIN, D. R. 1934. Marking bats. *J. Mammal.*, **15** : 202-207.
- GRIFFIN, D. R. 1940. Migrations of New England bats. *Bull. Mus. comp. Zool. Harvard*, **86** : 217-246.
- HALL, E. R. 1962. Collecting and preparing study specimens of vertebrates. *Misc. Publs Mus. nat. Hist., Univ. Kans.*, **30** : 1-46.
- HALL, E. R. and DALQUEST, W. 1963. The mammals of Veracruz. *Publ Mus. nat. Hist., Univ. Kans.*, **14** : 165-362.
- HAMILTON-SMITH, E. 1966. Portable Constantine trap. *Aust. Bat Res. News*, **5** : 2-3.

- HANDLEY, C. O., JR. 1967. Bats of the canopy of an Amazonian forest. *Atlas Simp. Biota Amazonica Zool.*, **5** : 211-215.
- HANDLEY, C. O. JR. 1968. Capturing bats with mist nets. IN : *Bats and Bat Banding* : 15-19. *Resour. Publs Bur. Sport Fish and Wildl.*, **72** : 1-48.
- HITCHCOCK, H. B. 1963. An unintended bat trap. *J. Mammal.*, **44** : 577-578.
- HUEY, L. M. 1936. Desert pallid-bats caught in mouse traps. *J. Mammal.*, **17** : 285-286.
- HUMPHREY, P. S., BRIDGE, D. and LOVEJOY, T. E. 1968. A technique for mist-netting in the forest canopy. *Bird-Banding*, **39** 43-50.
- JACKSON, H. H. T. 1926. Catching bats with gill-nets. *J. Mammal.*, **7** : 231.
- KILLPACK, M. L. and GOATES, M. A. 1963. Bat captured in snap trap. *J. Mammal.*, **44** : 125-126.
- KNUDSEN, J. W. 1966. *Biological techniques. Collecting, preserving and illustrating plants and animals* xi+1-525. Harper and Row. Publ., New York.
- KUNZ, T. H. 1982. Roosting ecology. IN : *Ecology of Bats* : 1-55. T. H. Kunz (ed.), Plenum Publishing, New York.
- LEVI, H. W. 1966. The care of alcoholic collections of small invertebrates. *Syst. Zool.*, **15** 183-188.
- LUCAS, F. A. 1950. The preparation of rough skeletons. *Sci. Guide Am. Mus. nat. Hist.*, **59** : 1-20.
- LYMAN, S. H. 1926. Collecting bats with a net. *J. Mammal.*, **7** : 230.
- NAGORSEN, D. W. and PETERSON, R. L. 1980. Mammal collector's manual. A guide for collecting, documenting, and preparing mammal specimens for scientific research. *Misc. Publs Life Sci. R. Ont. Mus.*, unnumbered : 1-79.
- PHILLIPS, C. J. 1988. Preparation and storage of fluid preserved specimens. *Proc. Wkshp Mgmt Mammal Colln Tropical Environ.* 283-302.

- PINE, R. H. and DUNCAN, W. B. 1975. Bat versus flypaper. *Bat Res. News*, **16** : 9.
- PRIMROSE, C. 1936. The preparation of specimens of bats. *J. Bengal nat. Hist. Soc.*, **10** : 146-161.
- QUAY, W. B. 1974. Bird and mammal specimens in fluid—objectives and methods. *Curator*, **17** : 91-104.
- RAUSCH, R. 1946. Collecting bats in Ohio. *J. Mammal.*, **27** : 275-276.
- ROSEVEAR, D. R. 1965. *The bats of West Africa* : vii+1-418, Trustees British Mus. Nat. Hist., London.
- SANBORN, C. C. 1936. Records and measurements of neotropical bats. *Fld. Mus. nat. Hist., Zool. Ser.*, **20** : 93-106.
- SETZER, H. W. 1968. Directions for preserving mammals for museum study. *Inf. Leaf. Smithson. Instn*, **380** : 1-19.
- SMITHERS, R. H. N. 1973a. *Recording data on mammal specimens* : 11 pp. Trustees Natn. Mus. Monum. Rhodesia, Causeway.
- SMITHERS, R. H. N. 1973b. *Mammals. The preparation of museum study skins* : i+1-12. Trustees Natn. Mus. Monum. Rhodesia, Causeway.
- de la TORRE, L. 1951. A method for cleaning skulls of specimens preserved in alcohol. *J. Mammal.*, **32** : 231-232.
- TUTTLE, M. D. 1974a. Bat trapping : results and suggestions. *Bat Banding News*, **15** : 4-7.
- TUTTLE, M. D. 1974b. An improved trap for bats. *J. Mammal.*, **55** : 475-477.
- TUTTLE, M. D. 1976. Collecting techniques. *Biology of Bats of the New World Family Phyllostomatidae. Part 1* : 71-88. R.J. Baker, J. K. Jones and D. C. Carter (eds), *Spec. Publs Mus. Texas Tech Univ.* No. 10.
- TUTTLE, M. D. and STEVENSON, D. E. 1978. Variation in the cave environment and its biological implications. IN : *Proceedings of the National Cave Management Symposium* : 108-121, R. Zuber, J. Chester, S. Gilbert and D. Rhodes (eds.). Adobe Press, Albuquerque.

- VAN TYNE, J. 1933. The trammel net as a means of collecting bats. *J. Mammal.*, **14** : 145-146.
- VILLA-R., B. 1966. *Los murciélagos de México* : xvi+1-491, Univ. Nacional Autónoma de México, Inst. Biol., México.
- WAGSTAFFE, R. and FIDLER, J. H. 1968. *The preservation of natural history specimens* (vol. 2) : xv+1-404. Philosophical Library, New York.
- WHITAKER, A. H. 1972. An improved mist net rig for use in forests. *Bird-Banding*, **43** : 1-8.
- WILSON, N. 1965. Red bats attracted to insect light traps. *J. Mammal.*, **46** : 704-705.





## COLLECTION METHODS FOR MEDIUM-SIZED MAMMALS

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Mammals range from tiny-sized shrews of *c* 50 mm length to gigantic blue whale of *c* 50 m length, and their average size will be something much larger than the largest living land animal like elephant of *c* 3m in length. There is no such term used as “medium-sized mammal” *sensu stricto* in the technical usages, although, often the term ‘medium-sized’ is used when intra-group references are made. For convenience, the so called medium-sized mammals may be defined to include arbitrarily the mammals in the group-size from mongoose to monkeys, *i.e.*, roughly between 30 cm and 1 m in length. In the Indian context, there are some 375 odd species of mammals known from the region. Of them, the following groups of animals may be included in the ‘medium-sized’ category :

- Primates — all species except *tree-shrews* and *lorises*.
- Carnivora — most species excluding Pantherinae, Acinonichinae, Ursidae and Hyanidae.
- Artiodactyla — only Tragulidae.
- Pholidota — all species.
- Lagomorpha — all species except Ochotonidae.
- Rodentia — Hystricidae, Petauristinae, *Ratufa*, *Marmota*, Rhizomyidae.
- Cetacea — *Platanista*.

In the present context, however, the terrestrial mammals are the only concern.

Zoological collecting involves ‘procurement of specimen’ (live or dead), and ‘preparation of museum specimen’ in order to incorporate them in a standard zoological collection for conventional studies and researches. The first part of zoological collecting, *i.e.*, procurement of specimens demand a great skill and prudence. A proper planning is necessary for any collecting endeavour. In doing so, the first question should be ‘what to collect’ and this will, in turn, bring in ‘where to collect’ and ‘when to collect’ The answer to ‘what to collect’ is determined by the need of the zoological collection for the scientific investigation in

general or for any specific purpose. The want-list should not only include the name of the species, but also should specifically narrate which part of the animal is to be sought, particularly for the special specific investigation. However, for general taxonomic studies the standard zoological material in mammals consists of "skin", which includes the entire skin with the appendicular part of the body ; the "skull", which includes the cranium with the adjoining bony parts together with the lower jaw and sometimes with horns or antlers as the case may be ; and "baculum" or "os penis" of some mammals. Besides the above-mentioned material, often many other visceral parts, skeletal parts, stomach-contents, faecal matter in the form of pellets and scats, nesting material, and any other material associated with the animal which plays significant role in the life of the animal are also taken as specimens for the zoological collection, as supporting material. All these objects that are required for zoological collection need specific treatment or preparation so that they will last as study material for future reference and this would be the second part of the zoological collecting.

While making plans for 'what to collect', a requisite permit to collect specific mammals is necessary in the Indian context under the pervuew of the Wild Life (Protection) Act, 1972. The permit may be obtained from the Chief Wildlife Warden or the Chief Conservator of Forests of the State concerned. Although the Act has provisions for collecting zoological specimens for scientific research, in practice, the permit is generally issued to authorised bodies carrying out scientific studies and research in recognised institutions. Moreover, only the species listed under the Schedules III, IV, and V and unscheduled species (if any) are ordinarily allowed for collecting. For the other species included in Schedules I and II, a special permit is essential. Besides for a permit for collecting for scientific research, there are provisons in the Act for game licences of different categories issued for specific forest blocks and for specific types of animals and also for specific period for hunting or live trapping of some restricted number of animals.

After determining "what to collect," the next step eventually will be "where to collect" For this purpose, the range of distribution of the species concerned is determined first and then the suitable areas are selected where most of such species are expected to occur. Sometimes the area may be stretched over various administrative jurisdictions and in those cases administrative formalities with all concerned bodies are to be cleared. The next step will naturally be "when to collect," *i.e.* which part of the calender year should be chosen. It is a very important point because, in India different seasons of the year differ to offer various facilities as well as difficulties. Moreover, the local sentiments and other factors like issues concerning geopolitical, socioeconomic and

exigencies of the land and the people may pose difficulties, if not impossibilities to carry out collecting work. Again, all the three above mentioned stages of collecting may turn up in micro-level. For example, in "what to collect", one has to be particular which individuals of a species are required in respect of age, sex, etc. ; and in "where to collect," one has to look for the convenient site or location not only for encounter with the animal but also for proper application of collecting gear and also for recovery and retrieval ; and in "when to collect," the timings in terms of clock hours is to be determined, for instance, nocturnal animals are to be sought for in the darkness of night and so forth. A particular species should be looked for during a particular hour of the day when such animal is expected most in a particular site for particular performance of its activities.

For the purpose of collecting zoological specimens various methods are applied and this is "how to collect" part of the story. This involves trapping of animals or hunting of animals in general. Trapping may involve live trapping or snap trapping which may injure or kill the trapped animal. Various types of traps, both conventional or unconventional, may be applied for the purpose. Efficiency of all types of traps, however, depends largely on the skill and experience of the trapper in the way of selection of right type of trap, bait, site and the time provided for setting the trap. Sometimes the number and arrangement of traps also determine the success of the trapping. For most medium-sized mammals the live traps like cage type or box type are suitable and safe and also uncontroversial. Net traps are convenient for timid type of animals like hares in particular. Snares and poison baiting are often applied for vermin species, but are not recommended. Most of the traps used popularly are conventionally uncontrolled ones, *i.e.*, the animals are trapped by themselves in such traps. There are, however, many types of traps which are controlled by attending persons from a distance.

Besides trapping, conventional hunting by use of firearms is an important method and practiced almost universally. For most of the medium-sized mammals, 12 bore shotgun with No. 4 shot is suitable. Small bore rifles are also convenient weapons for such hunting. Certain precautions are to be rigorously followed while hunting with firearms. Safety of the hunter and safety of unwanted intruder in the field of action should be watched. Range of the shot as well as the arm in use should be carefully judged in order to be sure to kill or fatally injure the target animal. Careful watch should be kept on the shot animal. Often it may take sometime for the animal to be dropped after the shot injury. As soon as the animal is dropped one has to be sure that the animal is dead before handling it. On occasions the animal shot may be injured but is capable of inflicting injury to the handling person or is able to escape. Most of the medium-sized mammals

are capable of biting or scratching. It should be safe to keep the injured animal pressed against the substratum by a suitable stick or apply a few blows with a blunt instrument to kill it. Care should be taken not to damage the skull or other delicate parts of the animal's body. Retrieval of the shot animal often pose difficulty specially amidst the thick cover of undergrowths or in an undulating terrain. Therefore, the terrain should be carefully studied and chances of retrieval adjudged before shooting an animal.

After procurement of the specimen dead or alive, it should be brought soon to the field laboratory for preservation. The hot and humid climate accelerates the process of decay of dead animals. After sunrise, especially when the days are hot, preparation work should be started within a few hours after the specimen is killed, but this period may be extended a little further during the winter or cold days. The traps set during day-hours should be frequently checked and those set during night hours be checked well before the morning gets hot.

In the field laboratory, the preparation work begins with the recording of the standard measurements and other characteristic features necessary for scientific studies. An individual animal may be prepared as a dry or a wet specimen. For wet specimen a fluid preservative is used. Formaldehyde solution is one of the popular chemicals used for fixation. A solution of about 10-12% strength is prepared in a quantity about 10-12 times the volume of the animal to be fixed. The same fluid is injected liberally in the viscera till the fluid oozes out through various orifices of the animal. The animal is then properly set in a container providing a suitable posture for convenient study and the fixative fluid is poured in the container to immerse the animal completely. Sometimes a suitable weight may be required to keep the animal immersed in the fluid. After keeping the animal in the fixative solution for overnight, the fluid is changed by a fresh solution and left for another half a day. By this time the animal gets fixed. It is then transferred to the lower strength of the fixative-fluid, such as 4% formaldehyde solution, where it may be preserved for an indefinite period. Sometimes instead of injecting the fluid, a slit is made in the abdomen of the animal with a sharp knife to facilitate the entry of the preservative fluid into the viscera. Each animal thus fixed is properly labelled and wrapped in a piece of white cotton-wool and stored immersed in the preservative fluid. Besides formaldehyde solution, many other chemicals are also used for fixation as well as for preservation in the fluid medium. The conventional option is the ethyl alcohol. Fixation is done in alcohol of 90-95% strength and preserved in 70-80% strength. The alcohol-fixation necessarily requires a longer period and frequent changes of the fluid. Normally three changes during 48 hours are sufficient to fix a specimen. Although various formulae for fixation and preservation of

tissues for histological studies are also used for fixation and preservation of the zoological specimens but this is done for special and specific study purposes. In general, the fluid medium that may stain or change the colour of the animal is avoided for conventional preservation of zoological specimens.

For dry specimen, the art and craft of taxidermy have to be applied for curing the animal to be preserved. It involves skinning, tanning or fixation, and preparation of the museum specimen in the form of a "skin". In skinning, the skeletal and muscular parts of the torso of the animal are taken out to retain the entire skin with the fur and the external skin derivatives. The skin part is then fixed or tanned. Along with the skin, the skull and baculum are also cleaned and preserved as zoological specimens. The material collected and thus prepared is packed carefully to be transported to the laboratory or the place of research. In the tropical climate, care should be taken to save the zoological specimens in the field and also in the laboratory from moisture, fungal infection, attacks from injurious pests, etc. In the field it is very important to take special care of the material collected. Again, storage of zoological specimens in the same context is equally important. Fluctuation of temperature *vis-a-vis* moisture in different seasons of the year affect very much the life of zoological specimens, unless precautionary measures are taken in time. In fact, fluctuation of temperature and moisture may create a suitable condition for the pests to breed and feed on the derivatives of animals, especially the dry skins.

### SUMMARY

Medium-sized mammals may be defined to include arbitrarily the mammals in the group size from mongoose to monkeys, *i.e.*, roughly between 30 cm and 1 m in length.

Zoological collecting involves procurement of specimen and preparation of museum specimen. In planning any collecting endeavour the eventual series of questions are : What to collect, where to collect, when to collect and how to collect ? In the Indian context, under the pervuew of the Wild Life (Protection) Act, 1972, a permit must be obtained from the Chief Wildlife Warden or the Chief Conservator of Forests of the State for collecting zoological specimens. Ordinarily, animals of Schedules III, IV and V are allowed for collecting.

Of various methods applied for collecting, trapping and hunting by firearms are important methods universally practiced. Efficiency of all traps depends largely on the skill and experience of the trapper in the way of selecting right type of trap, bait, site and time provided. For

hunting with firearms, 12 bore shotgun with No 4 shots or small bore rifles are convenient weapons for the medium-sized mammals.

After procurement of animals, preparation work begins in the field laboratory, with the recording of the standard measurements. The animal is either preserved wet or dry. For wet specimen, fluid preservatives like formaldehyde solution or ethyl alcohol are conventionally used. The animal is fixed and then preserved. For fixation 10 to 12% formaldehyde solution or 90-95% ethyl alcohol is used and for preservation 4% formaldehyde solution or 70-80% ethyl alcohol is used. Before storing the specimens, each specimen is properly labelled and wrapped in white cotton wool. For dry preservation, art and craft of taxidermy have to be applied. The animal is skinned and then tanned. In skinning the skeletal and muscular parts of the torso of the animal are taken out to retain the entire skin with the fur and the external skin derivatives. Along with the skin, the skull and baculum are also cleaned and preserved. Care should be taken in the field as well as in laboratory to save the zoological specimens from moisture, fungal infection, attacks from injurious pests, etc., especially in case of the dry skins.

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## **FIELD PREPARATION TECHNIQUES, SMALL MAMMALS**

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### **INTRODUCTION**

Recent mammal collections are valuable resources for many disciplines like systematics, wildlife, agriculture, veterinary science, medicine, etc. As a result, considerable money and space are devoted for the proper storage, maintenance and utilisation of these collections. In developed countries, considerable attention has been given to this area of study. Numerous ideas concerning collection-management have been conceived and published (Lewis *et al.*, 1970 ; Chenhall, 1975 ; Williams *et al.*, 1977). But in a developing country like India, there is still a dearth of literature on this aspect. Except for the work of Biswas (1968) on the preservation of mammals for scientific study, practically nothing is known on other aspects of collection and management of mammalian specimens, in India.

In the present paper the techniques employed in India for the preservation of small mammals in the field are discussed.

### **COLLECTING**

It is difficult to draw a clear line of demarcation between small and medium-sized mammals. However, small mammals, as are considered here, include shrews, bats, rats, palm squirrels, pikas, etc. All these, except bats, are normally collected by trapping (Agrawal, 1979) and the latter with the help of mist nets or by picking from their roosts (Khajuria, 1965 ; 1977 ; 1979). Some are also collected with the help of firearms. However, in the latter case there are chances of damage to specimens especially to their skulls. Hence, currently collecting of small mammals by shooting with firearms is discouraged, as far as practicable.

Live specimens are killed in the field laboratory by exposure to chloroform or other vapour just before processing. But if a specimen is killed in the process of collecting, it is brought to the camp as early as possible, at least before it starts rotting.



## MEASUREMENTS

Prior to preservation, the external measurements (Ellerman, 1961 ; Khajuria, 1953 ; Roonwal and Agrawal, 1966) are taken and other data like sex, number and position of mammae, condition of gonads, number of plantar pads, etc., are noted. Ectoparasites, if any, are also collected.

External measurements are generally taken from freshly killed animals before *rigor mortis* has set in and with the body-parts fully relaxed. The body is pressed against a flat surface, but no stretching is allowed. All measurements are taken as straight distances between two parallels running through the two points of reference. The measurements are expressed in millimetres.

For small mammals the following body-measurements are generally taken (Fig. 1).

1. Head and body length—from the tip of nose to the anterior margin of the anus.
2. Length of tail—from the anus to the tip of the tail-vertebrae, excluding the pencil of hairs, if any.
3. Length of hind foot—from the outer surface of the heel to the tip of the longest toe, excluding the claw.
4. Length of ear—from the intertragal notch to the farthest edge of the pinna, excluding hairs.

In the case of bats, in addition to the above-mentioned measurements, the lengths of forearm, tibia, foot and claw, the length and breadth of nose-leaf, etc., are also taken.

The sex of the specimen is determined by examining its external genitalia. In case of doubt, however, it is advisable to examine the internal reproductive organs.

In females, the number, position and condition of mammae are noted. These are broadly classified as thoracic and abdominal. Thoracic mammae include axillary, anterior thoracic and posterior thoracic, and the abdominal mammae consist of anterior and posterior abdominal and inguinal. Sometimes the position of testes (abdominal or scrotal) and the condition of vaginal orifice (open or closed) are also noted. These give some indication as to the reproductive condition of a specimen.

The number of plantar pads in some murids, especially in the genus *Millardia* is helpful in the identification of different species within the genus. Hence, particulars of plantar pads are noted in case of murids.

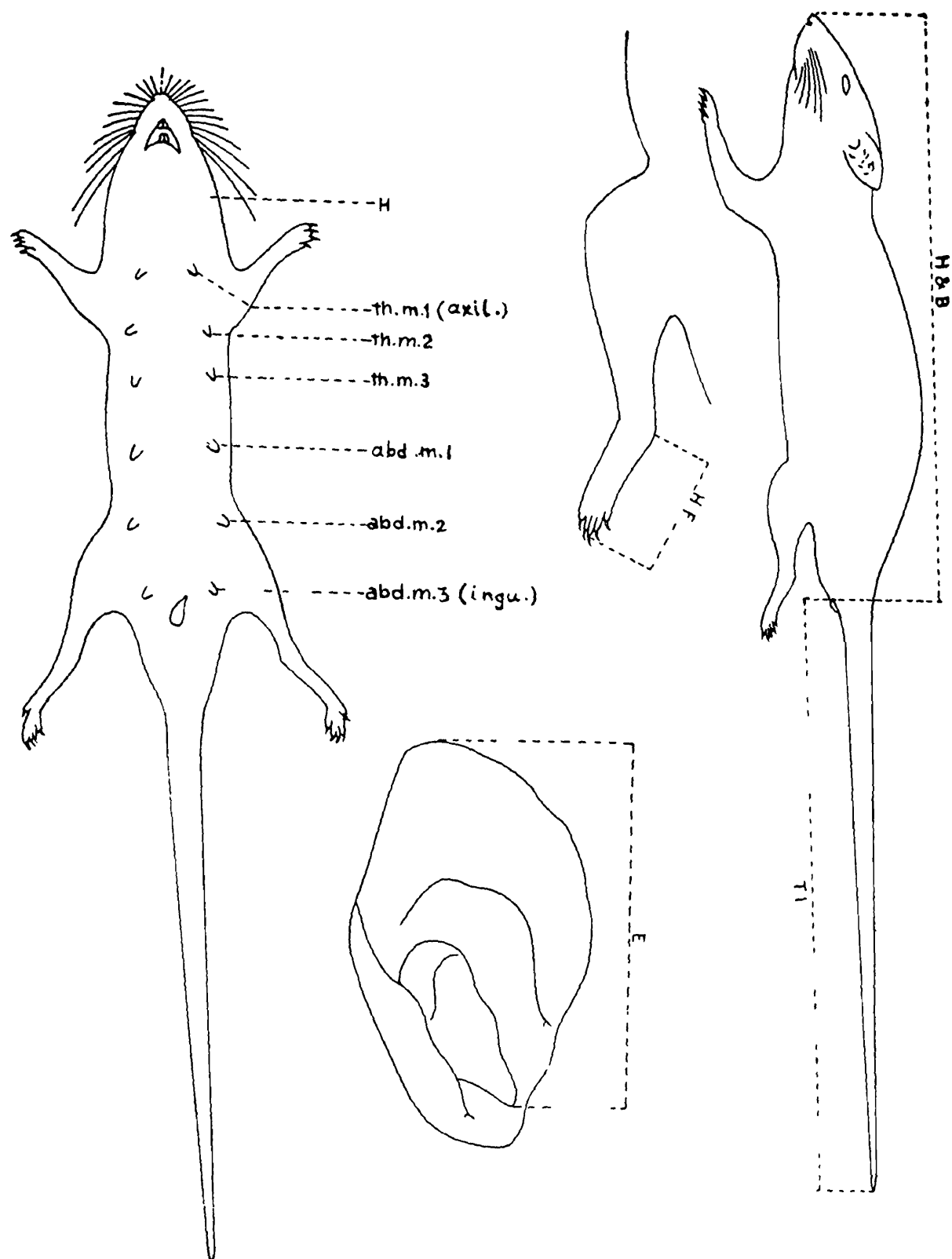


Fig. 1 : Dorsal and ventral views of the body, hindfoot and ear of *Rattus rattus*, showing body-measurements.

In recent years, the baculum has received increased recognition in the systematics of mammals. Many workers have pointed out the probable significance of this structure in assessing the relationship among bats and squirrels. Although the baculum can be extracted from an alcohol-preserved specimen, it is easier to take it out from the freshly killed one. Hence, as far as possible, the baculum is taken out, cleaned,

and preserved for future studies, in the field itself (Hamilton, 1946 ; Friley, 1947).

After accessioning the specimen in the field-book, a collection number/lot number is given against it. A field-label giving all the details like collection number, locality, date of collection, sex, name of collector, external measurements, brief description of habitat, ecological notes, if any, etc., is prepared and kept ready to be eventually tied to the processed specimen.

#### FIELD-PRESERVATION

The specimens are either preserved wet or dry. At least 50 % of the specimens of each species are made into study-skins (which facilitate the study of their colour, nature of fur, etc.) and the rest are either preserved wet or converted into skeletons. If per chance, a large number of specimens are collected in a day and if it is not possible to roll the desired number of specimens in the field, these are brought to the headquarters in the skinned condition and are afterwards given the shape. In any case, before processing, it is ensured that the specimen is not a decomposed one. The latter, if any, is converted into skeleton.

A list of articles required for the preservation of mammals is given by Biswas (1968).

#### WET-PRESERVATION

The popularly used word "preservation" actually includes two distinct processes—fixation and preservation. Either one chemical in different concentrations is used for both the processes or separate chemicals are used for each one of them. Normally 10 % formaldehyde solution (1 part 40 % solution of formaldehyde and 3 parts water) or 90 % ethyl alcohol is used as fixative and 4 % formaldehyde solution (1 part 40 % formaldehyde solution and 9 parts water) or 70 % ethyl alcohol as preservative. Sometimes the specimens are fixed in 10 % formaldehyde solution, but preserved in 70 % ethyl alcohol.

For proper fixing of the internal organs enough solution of 10 % formaldehyde is injected into the abdominal cavity so as to somewhat distend it. Alternatively, the abdomen is slit open along the mid-ventral line to expose the viscera. The extent of incision varies with the size of the specimen. Some amount of absorbent cotton is pushed inside the abdominal cavity through the slit to facilitate the inflow of fixative. The specimen is then given the desired shape in an enamel tray and is

kept completely immersed in formaldehyde solution of the above strength for 12 to 24 hours or more depending on its size, the volume of the fixative is maintained at about nine times the volume of the specimen. After it is thoroughly checked that the different body-parts of the specimen have been properly fixed *i.e.*, have become stiff, it is transferred to the preservative, which is either a fresh solution of 4% formaldehyde or 70% ethyl alcohol. However if a specimen fixed in formalin is to be preserved in alcohol, it is first thoroughly washed in running water, semidried, and then transferred to the latter. When the specimen is to be fixed in alcohol, the same procedure is followed as for the formaldehyde preserved specimen. The only difference is that the specimen is kept in 90% ethyl alcohol for a longer period *i.e.*, for two or three days, and then transferred to 70% alcohol.

In wet-preserved specimens, the skulls are normally left *in situ* till these are required for study. In the field, the specimens preserved wet are separately wrapped in absorbent cotton and stored in a large wide-mouthed polythene or copper container (Fig. 2) having a solution of 4% formaldehyde or 70% ethyl alcohol. However, it should be ensured that each specimen has a label tied to it.



Fig. 2 : A large wide-mouthed polythene container.

Whether to preserve a specimen in formaldehyde or in alcohol is a matter of one's choice. It is seen that the specimen preserved in alcohol decolours relatively quicker than the one preserved in formaldehyde. However, in the latter case, the specimen becomes too stiff. Moreover, handling of such a specimen becomes difficult because of pungent smell and corrosive action of formaldehyde. Hence, before study, such a specimen needs to be thoroughly washed in running water.

#### DRY-PRESERVATION

In dry-preservation, the skin of the animal is removed from the body and treated with chemicals to fix the tissue.

##### **Skinning :**

The animal is placed on its back. The fur along the mid-line of the abdomen is parted. With a scalpel the skin of the animal is cut longitudinally for about 2–3 cm. It is separated from the flesh over the abdomen and on each of the hind-limbs, with the help of fingers, until both the knee-joints are exposed. After loosening the skin round the knee, the joint is severed. The skin is separated all around up to the base of tail so that it can be grasped with two fingers. Magnesium carbonate is sprinkled on the inner surface of the skin to facilitate gripping. The skin is held on the base of tail by nails of the left thumb and forefinger and the tail-vertebrae are pulled out of the skin by the right hand (Fig. 3A). In some cases where the tail-vertebrae cannot be pulled out easily due to injury, etc., the skin of the tail is cut length-wise at the place of obstruction and the tail-vertebrae freed. Freeing of the skin from the body is continued forward turning it inside out. On each of the forelegs, it is freed upto the elbow joint and then the joint is severed. Freeing of the skin is continued further forward. The ears are cut as close to skull as possible. The eyelids are freed from the eyeballs with the point of a scalpel. Further anteriorly the skin is cut free at the nose by slicing it through the nasal cartilage. It is finally freed from the flesh by cutting it at the base of lips. The skin over the fore-and the hind-limbs is inverted as far as possible and the flesh over the remaining portion of the bones cleaned off. The fat below the skin is scraped off. The soft tissue from the sole is removed as much as possible through a slit made down the middle of it.

The lips are stitched and the skin is turned fur-side out. The blood stains, if any, are cleaned with cotton soaked in water. If the skin is too dirty, it is washed in cold water with soft soap. The fur is dried by using magnesium carbonate. The skin is again inverted. Moist alum

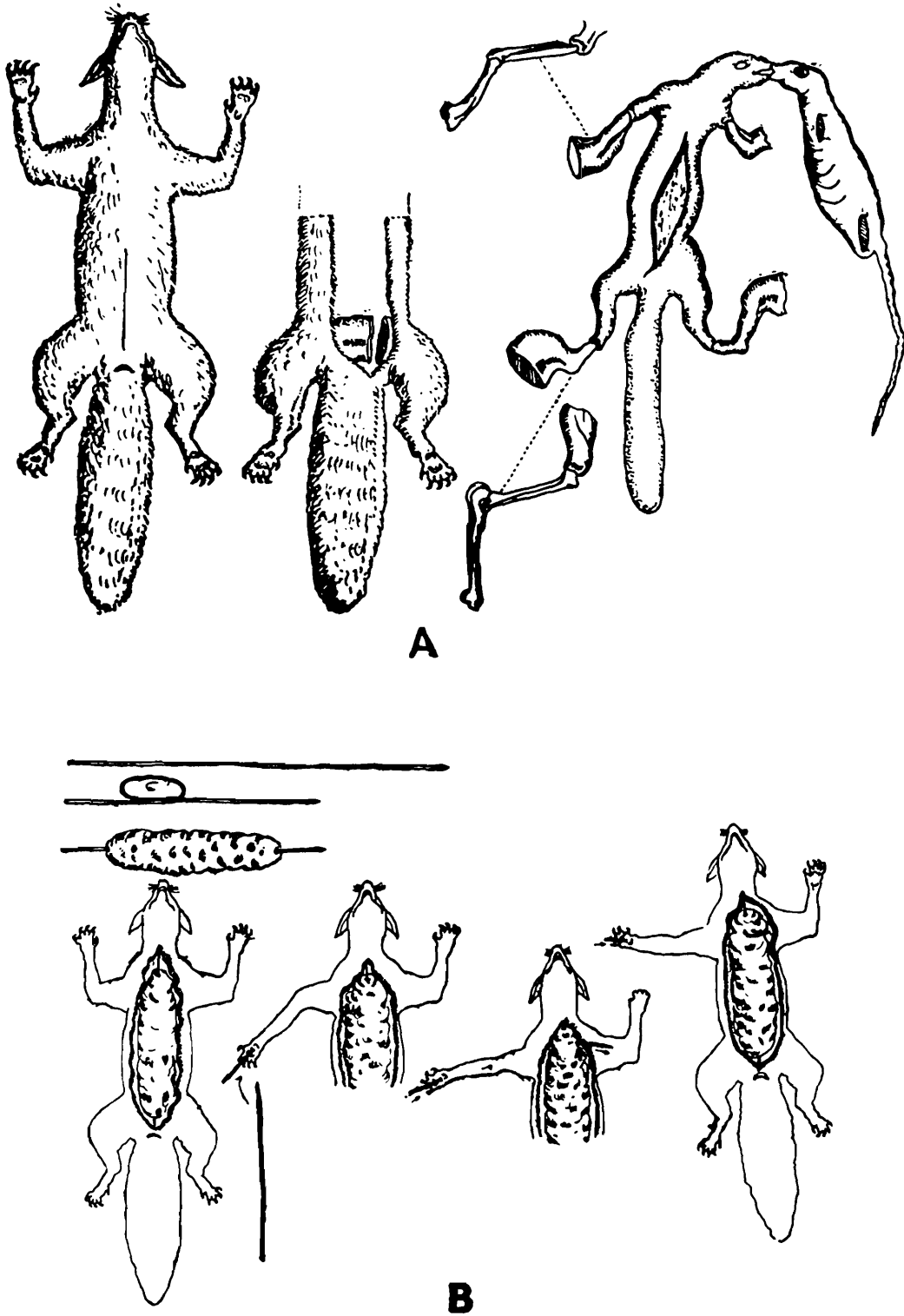


Fig. 3 : Process of skinning and rolling of a squirrel.

powder (alum pulverised) is rubbed throughout the skin's inner surface. Some quantity of alum powder is also inserted inside the hollow tail-skin with the help of a wire. Soft parts like lips, base of ears, sole of feet, etc., are painted with arsenical soap (a mixture of 900 g soft soap, 225 g arsenic trioxide, 50 g borax, 25 g camphor and 50 cc oil of turpentine). In case of a small specimen like a mouse, the application of the arsenical soap throughout the inner surface of the skin serves the purpose ; alum may not be used at all.



its tips filed to make it pointed. Some cotton-wool is twisted around the wire to make the structure approximately equal to the original thickness of the tail. A little arsenical soap is then smeared on it which is now inserted into the tail-skin. The limb-muscles are prepared by wrapping cotton-wool around the limb bones. The skin is turned fur-side out. An artificial body, somewhat similar in size and shape to the body removed, is prepared with cotton-wool and inserted within the skin. Little wisps of cotton-wool are inserted in the spaces between the outer skin and the artificial body, especially below the eyes, ears, nose, etc., to give the skin a proper shape. After this, the cut on the abdominal portion of the skin is cross-stitched (Fig. 3B).

Specimens other than bats are set on a piece of thermocol placing the limbs close and parallel to the body, the forelimbs pointing forwards

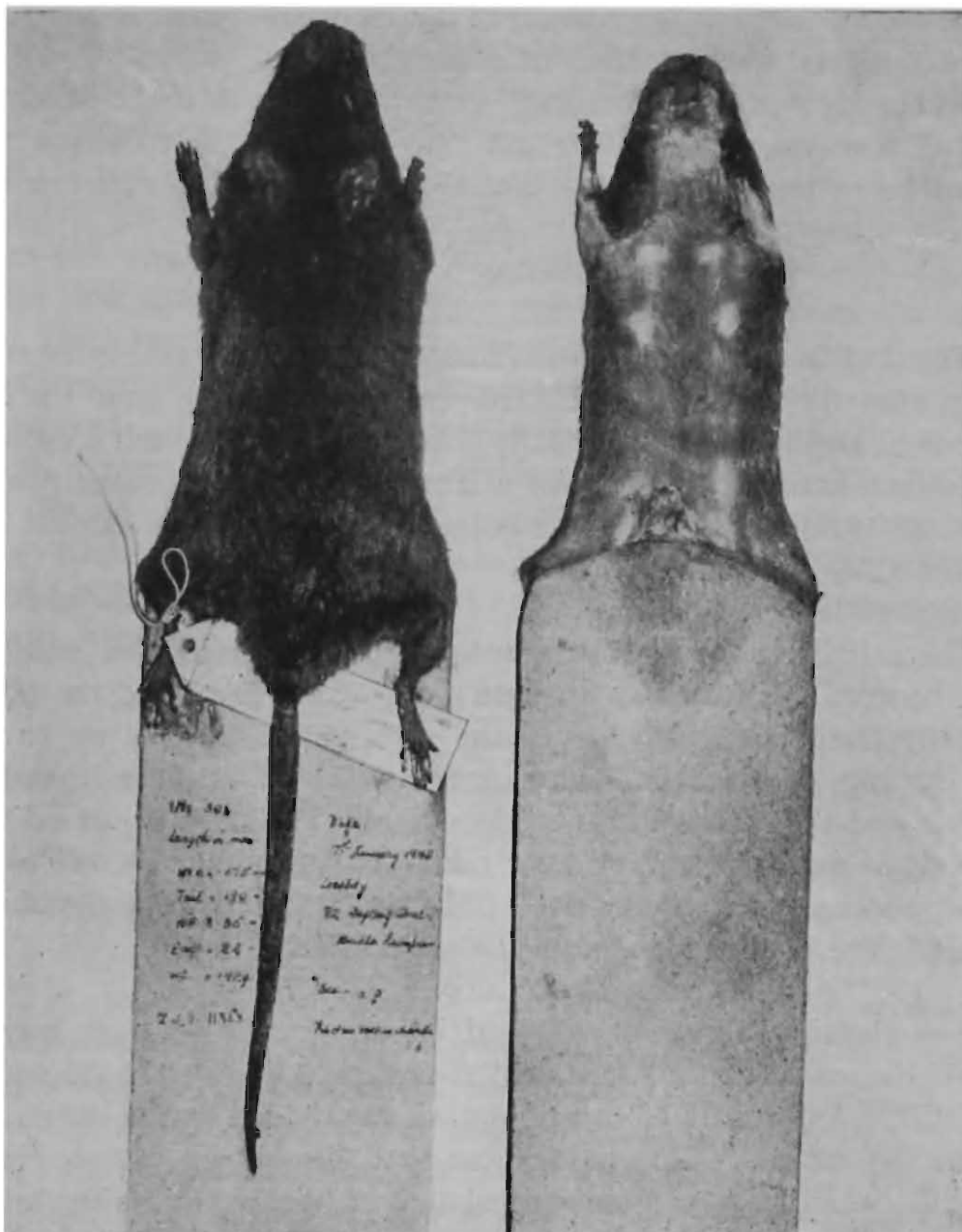


Fig. 5 : A skin of metad, preserved flat.



and the hindlimbs backwards. A thin layer of cotton-wool is wrapped from the nose to the neck of the specimen so that the whiskers lie backwards along the sides, and the ears lie flat on the head. It should be mentioned that keeping the ears erect in rolled skins, no doubt facilitate examination of both sides of the ear but is disadvantageous in storing and there is every likelihood of the ears being damaged. The specimen is left to dry in a shady, airy place.

In the second method, instead of making an artificial body with cotton wool, a piece of thin card-board is cut to the approximate size and shape of the head and body of the animal and inserted into the skin. The fore- and hindlimbs are folded over the card-board on the ventral side and the tail is set straight on the dorsal side. Each limb and the tail are then fixed in position either with the help of an adhesive tape or by a loop of thread. The practice of using adhesive tape is discouraged because the adhesive may melt and stick to the fur of the specimen as also to those of other skins and damage them. The dried skin is separately wrapped in a thin sheet of tissue-paper or a piece of newspaper. The paper not only protects the specimen from external injury during transit but also absorbs the residual moisture in it.

#### PREPARATION OF SKULL

The skull of each study-skin of mammal must be available for study. Hence, after the specimen is skinned, the skull is cut off from the body at the neck region and is either fully cleaned in the field itself (depending on the time available) or is given a label with a number corresponding to that of its skin, and stored in a 'kilner' jar, in 70% ethyl alcohol or in 4% formaldehyde solution.

For extracting the skull of a wet-preserved specimen, an incision is made between the two jaws on both sides of the head and the skin is gradually freed posteriorly up to the neck and anteriorly up to lips, with the help of a scalpel. The ears are sliced off as close to skull as possible and the eyelids cut over the eyeball. The skull is cut off from the body at the neck region. After taking out the skull, a small ball of cotton, approximately of the size of the skull, is put inside the skin of the head, and the lips along with the incision are stitched.

For cleaning, the skull is boiled in water until the flesh becomes soft. If the muscles of a formaldehyde-preserved specimen have become very stiff, a few pellets of caustic potash are added to the water. This softens the muscles. Care is taken so that there is no over-boiling of the skull, which may cause disarticulation of bones. Now with the help of a pair of forceps and a scalpel all the flesh is removed from the bones. The thin layer of connective tissue needs to be scraped off. The

brain is scooped out through the foramen magnum, either with a piece of flat-tipped wire and repeated washing in water, or by forcing water inside the cranium through a syringe. The skull is now thoroughly washed and dried. It is either tied to the skin or kept separately in a glass vial with a label bearing the same collection number as that of its skin.

A specimen to be converted into skeleton is generally preserved in 4% formaldehyde solution, in the field. In case of larger specimens, the bones are partially cleaned and dried thoroughly in the sun. These are finally cleaned in the laboratory.

#### PREPARATION OF BACULUM

The penis is cut from the specimen as close to the skin as possible. Care is taken that no portion of the baculum is cut. The penis is kept in 1N solution of caustic potash for softening the tissues. The time which depends on the thickness of the tissue, ranges from two to twelve hours. If the baculum is not very small and cartilaginous, the penis can safely be kept overnight in the solution. After this the adhering tissues are removed by holding the baculum at one end with a pair of forceps and teasing the tissue by a needle, under a binocular microscope. Thick tissues remaining attached to the basal end may be cut out with a scalpel. The cleaned baculum is treated in 5% acetic acid solution and washed with water to return it to a chemically neutral condition. It is then preserved either in a dilute aqueous solution of glycerine or fixed dry on a cellulose acetate paper, and mounted on a pin. For future study a label is given to the baculum. Also, an entry is made on the label of the specimen to the effect that its penis has been cut away to extract the baculum.

#### SUMMARY

In the present communication, information relating to the processing of small mammals in the field, has been embodied.

Live specimens are killed in the field-laboratory by exposure to chloroform or ether vapour. Specimens collected with the help of firearms are, however, processed before these start decomposing. Prior to fixation, the external measurements are taken and other data like sex, number and position of mammae, number of plantar pads, etc., noted. Ectoparasites are also collected. At least 50% of specimens collected are preserved dry as study skins and the rest are either preserved wet or converted into skeleton.

The word 'preservation' includes two distinct processes—fixation and preservation. For both these processes either one chemical in different concentrations or separate chemicals are used for each one of them. Normally 10% formaldehyde or 90% ethyl alcohol is used as fixative and 4% formaldehyde solution or 70% ethyl alcohol as preservative. Generally, specimens are fixed in 10% formaldehyde solution and after thorough washing with water, are preserved in 70% ethyl alcohol. In wet preserved specimens, the skulls are normally extracted only when these are required for study.

In the dry method of preservation, the skin of the animal is removed from the body and treated with chemicals to fix the tissue. Then it is either given the shape by filling the cotton-wool or maintained flat by inserting a piece of card-board. The skull is cleaned after boiling in water. Two separate labels having the same collector's number are tied to both the skin and the skull.

The specimens to be converted into skeletons are generally preserved wet in 4% formaldehyde solution in the field and cleaned in the laboratory. However, in case of larger specimens, the bones are partially cleaned in the field itself and then dried.

#### ACKNOWLEDGEMENTS

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#### REFERENCES

- AGRAWAL, V. C. 1979. Techniques for the study of rodent population. *Zoologiana*, 2 : 71-78.
- BISWAS, B. 1968. Mammals : their collection and preservation for study. In : A Handbook for Zoological Collectors, pp. 139-152, Director, Zoological Survey of India (Ed), Government of India, Calcutta.
- CHENHALL, R. C. 1975. Museum cataloguing in the computer age. *Am. Ass. State Local Hist.*, Nashville, Tennessee.
- ELLERMAN, J. R. 1961. The Fauna of India including Pakistan, Burma and Ceylon. Mammalia (2nd ed.), Vol. 3 (Rodentia). Part 1. Government of India, Calcutta.

- FRILEY, C. E. 1947. Preparation and preservation of baculum of mammals. *J. Mammal.*, **28** : 395-397.
- HAMILTON, W. J. 1946. A study of the baculum in some North American Microtinae. *J. Mammal.*, **27** : 378-387.
- KHAJURIA, H. 1953. Taxonomic studies on some Indian Chiroptera. *Rec. Indian Mus.*, **50** : 113-128.
- KHAJURIA, H. 1965. A novel method of capture of Indian Flying Fox (*Pteropus giganteus* Brunnich) for meat, fur and control. *Cheetal*, **8** (1) : 38-40.
- KHAJURIA, H. 1977. New methods of collection of rare bats. *J. Bombay nat. Hist. Soc.*, **71** : 600-601.
- KHAJURIA, H. 1979. Effectiveness of Japanese mist nets for catching Indian bats. *J. zool. Soc. India*, **28** : 152.
- LEWIS, S. D. and REDFIELD, A. 1970. Care of osteological collections. *Mus. Anthr., Univ. Missouri-Columbia, Mus. Briefs*, **4** : 1-18.
- ROONWAL, M. L. and AGRAWAL, V C. 1966. The measurements of rodents (Mammalia) particularly skull, for taxonomic purposes. *Rec. Indian Mus.*, **60** (1962) : 81-93.
- WILLIAMS, S. L., LAUBACH, R. and GENOWAYS, H. H. 1977. A guide to the management of recent mammal collections. *Carnegie Mus. nat. Hist., Spec. Publ.*, (4) : 105 pp.

#### DISCUSSION

- Q. What is the chemical name of rectified spirit.
- A. Ethyl alcohol.
- Q. Is the formalin solution used both for fixation and preservation, buffered with anything to prevent decalcification of the bones.
- A. Two to three spoon-full of common salt (sodium chloride) are added per litre of the formalin solution. Normally, specimens are preserved in 70% ethyl alcohol.

- Q. Please elaborate on your experience with carded-specimens. Is there a problem with losing parts. Is there any effort to remove grease from cards ?
- A. Carded-specimens of small mammals like rats are being maintained in the National Institute of Virology, Pune. The limbs are stitched to the card-board. There is no problem of greasing at least in the last two decades.
- Q. Is 4% formalin adequate for preserving mammal material?
- A. Actually 4% formaldehyde solution is adequate for preserving mammal material. More than this strength will make the specimens very hard and brittle.

## **FIELD PREPARATION TECHNIQUES, MEDIUM AND LARGE-SIZED MAMMALS**

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### **INTRODUCTION**

During the late 1800s and the early part of this century, the development of North American museum exhibits was in its heyday and field work was conducted throughout the world in search of mammal specimens for display. Hornaday (1891) provides an early account of preparation of larger mammals in the field for taxidermy mounting. This book is directed to the field naturalist and collector of that era. During this period, mammal specimens were also systematically collected and maintained in growing research collections. Consequently, field preparation techniques of study specimens were greatly influenced by taxidermy procedures. Many of these taxidermy procedures are not necessarily appropriate for the preparation of scientific specimens.

Modifications of preparation methods can be derived from a review of the available literature since that earlier time. Anderson (1965), Anonymous (n.d.), Anonymous (1911), British Museum (Natural History) (1968), DeBlase and Martin (1981), Hall (1962), Knudsen (1966), Miller (1912), Nagorsen and Peterson (1980), Rowley (1925), Setzer (1968) and Wagstaffe and Fidler (1968) are references that provide insight on both techniques and the improvement of preparation quality. This paper presents field preparation techniques that are suggested for medium and large-sized mammals. Mammals larger than the size of the larger species of North American squirrels (for example, *Sciurus niger*) are considered. These large mammals usually are not obtained on a regular basis in North America. Nonetheless, larger specimen preparation should receive the necessary time and proper consideration in the field.

Hall (1937, 1962) established a preparation principle that should stand as our primary goal. Although different preparators of equal experience may use different methods, "each preparator should constantly strive to improve the quality of his product. The aim should be firm, symmetrical skins free of all fat." Other factors concerning shape, durability, field applications of preservatives and solvents, and tanning

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procedures are considered here also because of their impact on space, expense, and potentially the long-term integrity of the scientific specimens in museum collections.

## MEASUREMENTS

The size range for the two categories of “medium” and “large” which are used in this paper, depends on the size limits of the storage facilities in the museum collection. In the Section of Mammals, Carnegie Museum of Natural History, medium-sized specimens are those that can be accommodated within the quarter-unit and half-unit storage case facilities, which house all stuffed skin preparations (Fig. 1). The inside dimensions of the trays for the quarter-unit cases measure approximately 57.5 cm in width by 91.0 cm in length, whereas those for the larger half-unit cases measure 144.0 cm in width by 97.5 cm in length. As will be seen under the respective preparation discussions, the size restrictions of these cases will determine whether the preparation is for a medium-sized or a large-sized mammal. These tray measurements are recorded for reference in the collector’s field notebook.

Field measurements of specimens should be taken soon after death while the body is limp and positioning for measurement is less difficult (Fig. 2). The following primary measurements are taken (terrestrial mammals): total length, length of tail, length of hind foot, and length of ear. Total length is measured from the tip of the nose to the tip of the last tail vertebra. The specimen should be placed on a level surface so that the backbone is in as straight alignment as possible. The measurement is taken at one side of the body or along the midline of the back, but not around the curves of the back. A steel tape is preferred by Anderson (1965) because it is not elastic and thus the measurements will be consistent. Tail length is taken from the base of the tail as it is bent upward at a right angle to the body, to the tip of the last vertebra. The hind foot should be measured with the leg extended and the foot bent at the ankle. This length is determined from the back of the heel to the end of the longest claw, or, from the tip of the “hock” to the edge of the hoof on ungulates. This differs from procedures of the British Museum (Natural History) (1968) where the claw of a non-ungulate is not included in the foot length. External ear length is determined from the inner base to the most distal tip of the pinna (not including hairs). The ear is held in a natural but erect position. Field weights are included when possible.

Different authors present a variety of additional measurements for taxidermy preparation (see Anderson, 1965; Anonymous, n.d.; Hornaday, 1891; Miller, 1912; Rowley, 1925). The various dimensions listed



Fig. 1.—Example of a half-unit specimen case with trays in the Section of Mammals, Carnegie Museum of Natural History. Note the difference in height between the flat, case-filled study skins (upper left) and the more naturally stuffed specimens (right) (*Agouti paca*) in the tray.

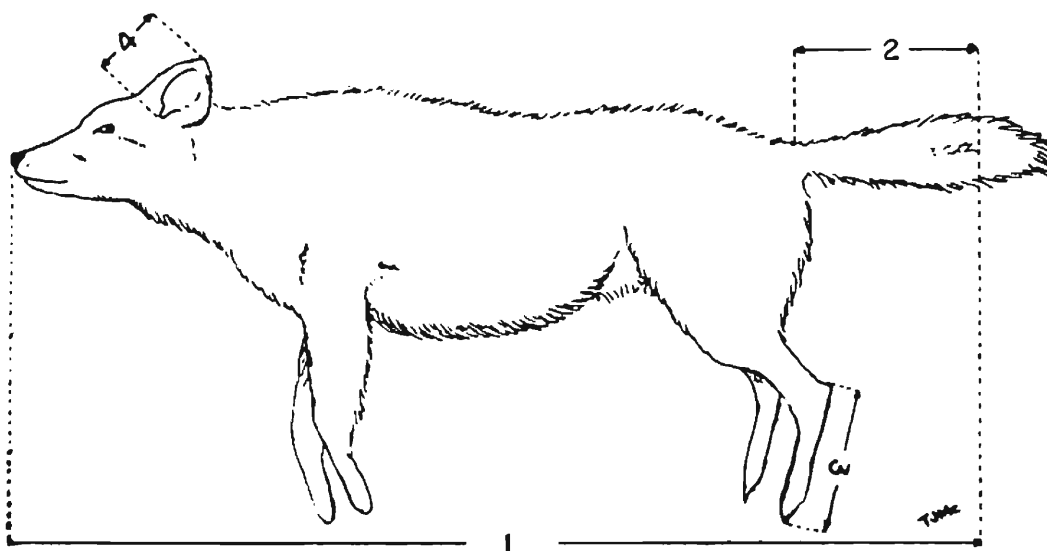


Fig. 2.—The four standard measurements taken from mammal specimens : (1) total length ; (2) length of tail ; (3) length of hindfoot ; (4) length of ear.



are not uniform among these accounts. Should an occasion for taxidermy preparation arise, it would be advisable for the field preparator to consult with the taxidermist.

For direct comparisons of morphological data from stranded cetaceans, The Committee on Marine Mammals, American Society of Mammalogists (1961) has standardised the necessary measurements. Twenty-two of the 36 measurements are presented in Fig. 3. Wagstaffe and Fidler (1968) discuss numerous measurements that are taken from stranded whales in order to produce scale models for study.

#### MEDIUM-SIZED MAMMAL PREPARATION

Taxidermy has had a strong influence on field preparations of medium-sized mammals (Hornaday, 1891). Two avenues were available during the early period for the preparation of study specimens. First, skins could be preserved wet in a salt-alum bath. This was considered efficient and time-saving, more specimens could be obtained. The specimens could be completed later, at the museum, as dry preparations (tanned or stuffed skins). Second, and encouraged as more suitable for study, the specimens could be prepared dry, stuffed for natural size and likeness.

Chemical preservation by salt-alum bath should never be considered. Some field collectors were still preserving field skins in this manner as late as 1937 (Clark, 1937). Rowley (1925) states that salt-brine, alone or in combination with alum or acid, changes the texture and affects certain colours in the hair. This causes negative, irreparable damage to the specimens decreasing their value for research (Hall, 1937). Hall (1937, 1962), Howell (1937) and Downing (1945) expressed their reservations and provided proof that salting alone can cause colour change. The use of borax can make a skin, brittle over time (Hall, 1968). Consequently, time and effort must be taken in the field to prepare dry study skins without using salt-alum baths, salt brine baths, acid, salt, or borax. Natural drying should be adequate to preserve the natural colour and texture of the pelage. All fat and connective tissue must be removed from the skin's inner surface in order to assist this drying process.

There are no known studies that assess tanning methods in terms of their application to research collections and the preservation of the scientific integrity of specimens (Hawks *et al.*, 1984). Tanning may be hazardous to the scientific value of the specimen. For example, it appears that the keratin structure of hair is altered by formaldehyde, strong acids, and alkalis. In addition, different tanning and storage procedures could produce skins that become susceptible to drying, tearing, stretching, chemical deterioration, or mildew.

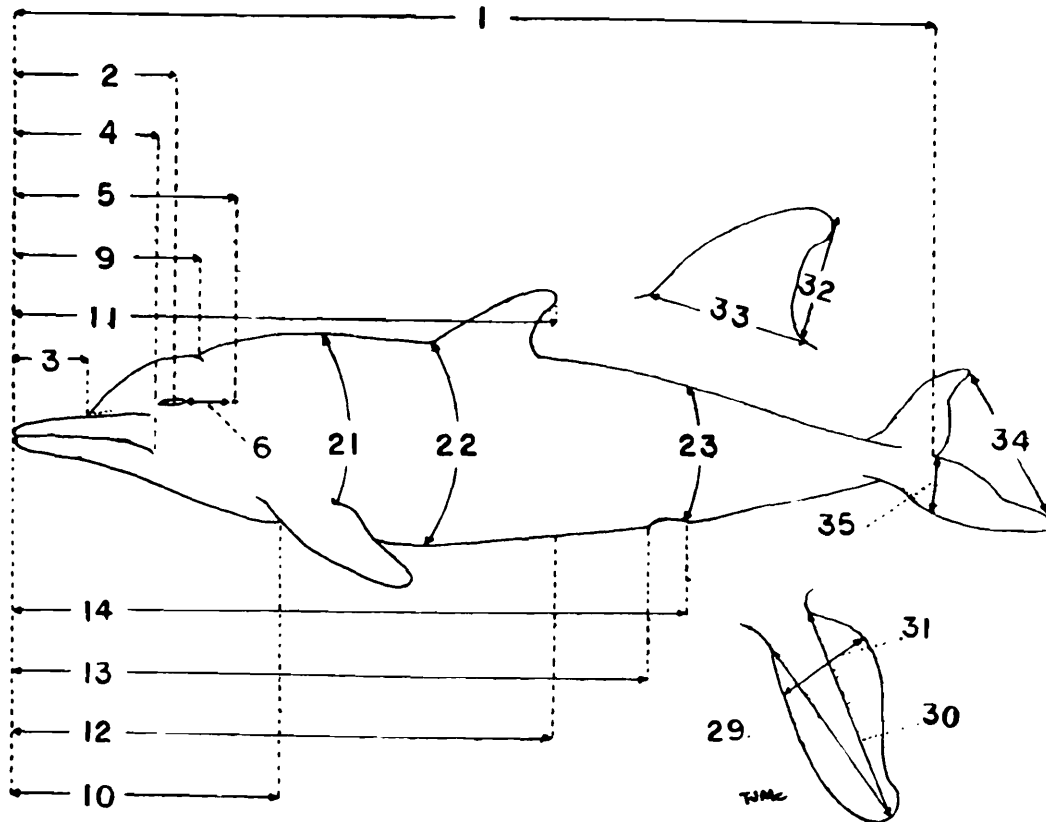


Fig. 3.—Twenty-two of the 36 measurements standardized for cetaceans by The Committee on Marine Mammals, American Society of Mammalogists. **LENGTH** : (1) total ; (2) tip of upper jaw to center of eye ; (3) tip of upper jaw to apex of melon boss ; (4) gape ; (5) tip of upper jaw to external auditory meatus ; (6) centre of eye to external auditory meatus ; (9) tip of upper jaw to blowhole along midline or of midlength of two blowholes ; (10) tip of upper jaw to anterior insertion flipper ; (11) tip of upper jaw to tip of dorsal fin ; (12) tip of upper jaw to midpoint of umbilicus ; (13) tip of upper jaw to midpoint of genital aperture ; (14) tip of upper jaw to centre of anus ; (29) anterior insertion of flipper to tip ; (30) axilla to tip of flipper ; (33) dorsal fin base ; (35) distance from nearest point on anterior border of flukes to notch. **WIDTH** : (31) flipper (maximum) ; (34) flukes (tip to tip). **HEIGHT** : (32) dorsal fin (fin tip to base). **GIRTH** : (21) on a transverse plane intersecting axilla ; (22) maximum ; (23) on a transverse plane intersecting the anus. Refer to The Committee on Marine Mammals, American Society of Mammalogists (1961) for further details.

A study skin preparation that replaces a carcass with a filler body of similar volume creates storage space problems and is vulnerable to mechanical damage in both the field and the museum. Specimens stored within bug-proof cases increase the vertical distance between storage trays. It is more convenient to flatten these specimens so that their height can be accommodated within the depth of the trays. The depth of most trays used in the Section of Mammals, Carnegie Museum of Natural History, range from approximately 4.5 cm to 5.5 cm. These trays are placed in runners located along each side of the case, which regulate the spacing between trays. Overly stuffed specimens exceeding the depth of these trays are exposed to potential damage when the tray is carelessly returned to the case (Fig. 1). Ears can be broken, the skin can be creased or ripped, and hair structures such as quills can be broken (Fig. 4).

Preparation of medium-sized specimens as flat, case-filled skins apparently began with a concern for preventing damage to fragile and thin-skinned specimens. Anderson (1961), Hall (1962), and Swenson (1954) discuss a sturdy and compact lagomorph preparation that was designed to prevent detachment of the large and heavy feet from the body and damage to the long ears and brittle skin. The resulting skin is flat with a rigid cardboard body supporting the outline of the specimen that accommodates the depth of storage trays and strengthens all appendages.

This method also can be extended to mammals larger than rabbits and hares. Consequently, the smaller ungulates and most carnivores can be prepared in this manner immediately in the field. Flat, case-filled skins are promoted as a preparation alternative in order to avoid the cost of tanning, produce research specimens free of chemical and mechanical damage, and reduce storage-space problems.

The skins of medium-sized mammal specimens are first case-removed, following the approach of the commercial fur traders (Henderson, 1975). The stretching of the skin and the removal of feet are avoided as unsatisfactory for scientific specimens. No mid-ventral incision is made. The incision begins at one heel with a scalpel or knife, cutting the skin at the back and inner side of a hind leg, across the pelvis between the anus and the external genitalia, and up along the other hind leg (Fig. 5). With a scalpel, work back the skin around each leg, separating flesh and fat from the skin. In many cases, the skin can be removed by pushing down with the thumb and fingers between the skin and carcass. Certain species such as porcupines can not be turned inside out and it is necessary to extend the primary incision from the tip of the tail to the neck (DeBlase and Martin, 1981). The feet can be disarticulated at the ankles or skinned to the claws. To prevent damage to the ventrum of the foot, it is necessary



Fig. 4.—Example of specialized structures such as porcupine quills (*Erethizon dorsatum*) that can be easily damaged by careless spacing between trays in the specimen case. The preparation of flat, case-filled study skins helps to avoid mechanical damage.



Fig. 5.—Example of case skin incisions. Pelvic incision connects those incisions along each leg ; the tail incision can extend from the tail tip to the base of the tail or completely to the pelvic incision.

to cut to either side to remove the skin. For the sake of obtaining a complete skeleton, it may be advisable to remove all the bones with the claws from at least one side of the body.

Many medium-sized mammals have scaly tails (for example, *Didelphis*, *Tamandua*, *Castor*, *Ondatra*) or bushy tails (for example, *Urocyon*, *Conepatus*, *Eira*) that need to be cut in order to remove the tail vertebrae without stretching or damaging the skin (DeBlase and Martin, 1981). The round or laterally compressed tails are slit along the mid-ventral line. The tail incision originates from the pelvic incision and continues, along one side of the anus, to the tail tip. With the legs freed, it is also possible to work back the skin to the rump and the base of the tail before cutting along the tail, (Fig. 5). The rectum is severed well inside the anus. The proximal tail skin for numerous mammals can be worked back for a distance without the need to split the tail before the skin becomes extremely difficult to remove. The tail is then split from that point to its tip.

The broad tail of the beaver (*Castor*) is split along a lateral edge. The skin is freed from the tail with a scalpel or knife. In some armadillos, the tail is completely enclosed with bony rings, which must be cut with shears to remove the tail (DeBlase and Martin, 1981). Formalin is injected into that distal portion of the armadillo's tail if it is impossible to remove.

The body skin is worked downward towards the head. When the hind legs are freed, the carcass can be hung, supported at spread legs or around the pelvis (Fig. 6). This way the skin can be removed evenly from around the body, allowing a downward pull from the weight of the skin. The forelimbs are handled in the same manner as the hindlimbs. The skin is removed from the head region with special consideration for severing each ear close to the base and detaching the eyelids and lips without damage (see further discussion for large mammal preparation).

The skin is removed from the carcass with the flesh-side-out. Without excessive stretching, the skin is positioned on a sheet of corrugated cardboard and the outline of the body is drawn and cut out (Fig. 7a). Some collectors prefer a "torpedo" outline tapering at the neck and head. An outline that considers body proportions can lend a more natural appearance. Time should be spent to draw a symmetrical body form. Large sheets of corrugated cardboard need to be taken to the field. Larger mammals with thick skin may require double sheets preferably with the second set of corrugations perpendicular to the first.

A sturdy hardwood stick of approximately 1.3 cm  $\times$  1.3 cm. dimensions is affixed ventrally to the mid-length of the flat body (Fig. 7a). The



Fig 6.—A convenient method for case-removing a skin by suspending the specimen (*Procyon lotor*) from its hind legs or from around its pelvis.

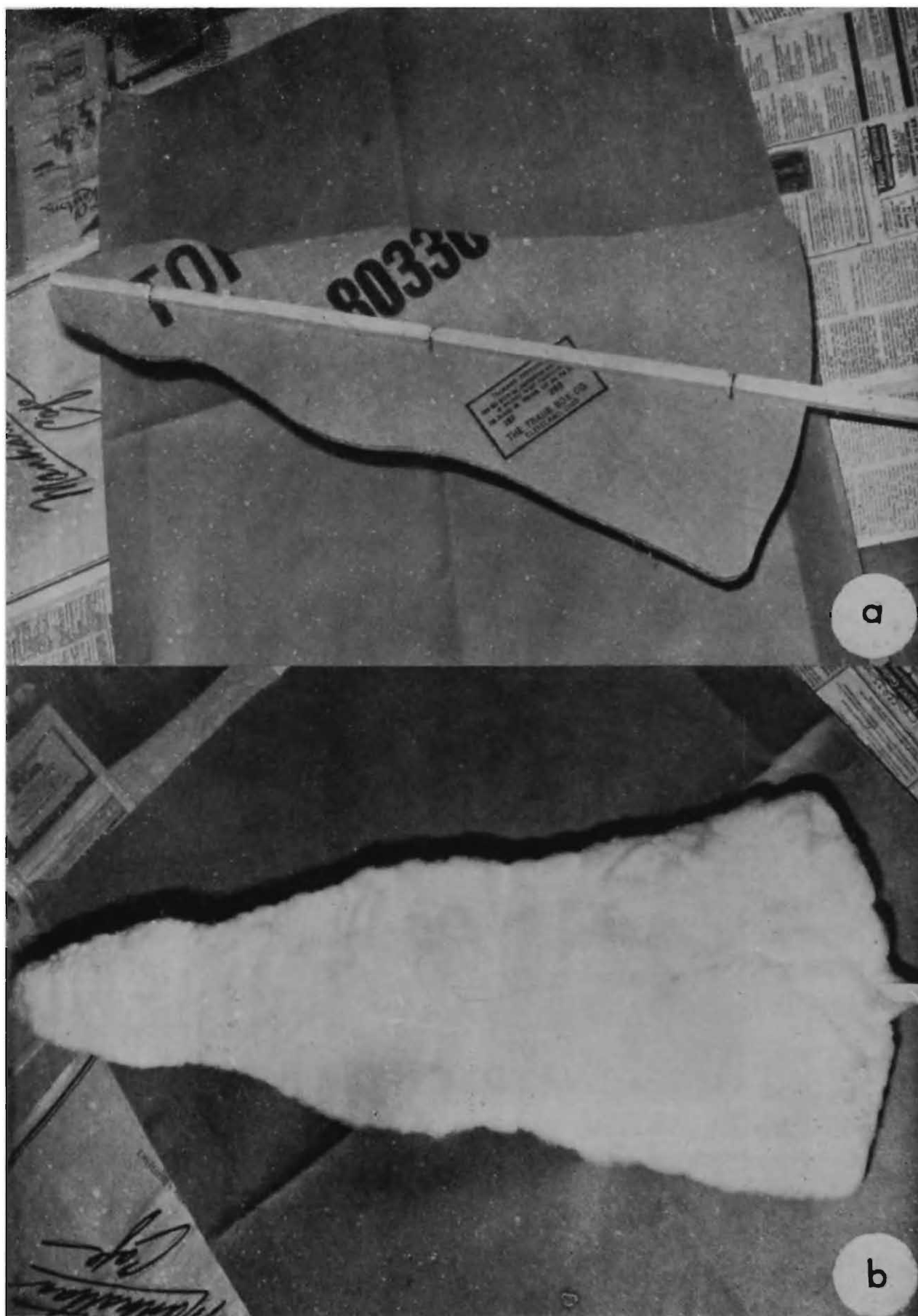


Fig. 7.—The support for a flat, case-filled study skin relies on a body outline of corrugated cardboard with a midrib hardwood stick attached to the ventral side (a). This flat cardboard body is completely wrapped in a layer of cotton, which is securely wound with cotton thread (b).

length of this midrib should exceed the length of the head and body and it extends from the nose tip (tapered) along the full length of the outline. Sticks cut from coniferous softwoods should not be used. Monel or other noncorrosive metal wire is looped through the board, around the stick, and tightly fastened at two or more points along the stick. A hardwood slat can also be attached along the posterior dorsal border of the cardboard flat to provide additional support during drying.

A layer of clean, combed cotton is wrapped around the cardboard body. Sterile cotton is preferred since it will be in direct contact with the skin. Cardboard is contaminated with chemical impurities and is acidic. This may possibly affect the specimen in time. The ends of this layer of cotton meet and are folded along the ventral midline ; thread can be wrapped around the flat body to hold the cotton in place (Fig. 7b).

While the skin is inverted, all fat and other tissue should be scraped away with a dull edge tool, such as a butter knife. Use with care so as not to cut the skin. A mammal such as the North American porcupine has a thin dorsal skin, besides quills that can be damaged. Fat deposition can vary through the year so more effort may be needed during one season than at another to remove all possible fat. Fat left on the skin can eventually work through the pelt, discolour the fur, and may even cause hair slippage. Fatty skin can be washed in warm water and detergent (Knudsen, 1966) or the fleshy side of the skin may be soaked in gasoline (Anderson, 1965) to remove fat and grease. Cornmeal and fine hardwood sawdust will quickly remove water from the fur. Wagstaffe and Fidler (1968) recommend washing in soapy water followed by full immersion for several hours in gasoline. After removing the skin, leave it until the gasoline evaporates. Greasy fur can be cleaned with an application of a gasoline-alcohol-turpentine mixture or carbon tetrachloride, trichlorethylene, or acetone (Wagstaffe and Fidler, 1968). Bloodstains should not be allowed to dry ; clean, cool water is used to remove blood (Knudsen, 1966). Hot water is excellent for softening and removing coagulated blood by dabbing the dry clots with cotton-wool and combing the hair. White gasoline is recommended when gasoline is used as a solvent. It has far less impurities that may cause hair colour change.

Similar to drying procedures used by commercial trappers, Nagorsen and Peterson (1980) suggest that the case skin be allowed to partly dry over a period of one day or more, while the skin is inverted and the flesh side is exposed. Grease can be wiped from the surface with a rag. All cuts in the skin need to be sewn and repaired on the flesh side before the skin dries and is reversed onto the flat body. A light spray of commercial strength formaldehyde can be applied to the cotton of the flat body to assist drying and repel flies during the final drying.



The inverted skin is oriented "nose-to-nose" with the flat body and worked right-side out onto the body (Figs. 8a, b). Adjust the skin without unnecessary stretching. Depending on the length of the legs and tail or the size of the feet, make a decision of how you want to orient these appendages. If the legs are long, these may be folded back on the body ventrum so the sole of one foot is showing while the back of the other foot is exposed for each pair. Legs and feet should not obscure important features on the ventrum. Specimens with short tails can have the hind feet and tails attached for support to the stick, which is allowed to extend beyond the body. This can also provide an appropriate handle, especially while handling specimens such as procupines. Feet and ears are stitched to the skin to dry close to the body. The long tails of certain species, such as arboreal examples, will need to be positioned along the left side of the preparation, stitched to the body at a couple of points for drying. Male specimens should have the penis severed close to its base on the carcass and leave it attached to the skin, where it should be everted, stitched to the belly, and dried in place.

The legs are reinforced with a heavy gauge monel wire so that they can be bent for position and support. A small amount of sterile cotton can be used to cover the wire. The feet can be packed with cotton if the bones have been removed. Wires should be inserted (in those with attached feet) on the dorsal side and extended into a longer toe. It is advisable to inject any attached feet, lips, nasal pads, or other fleshy parts with commercial strength formaldehyde to preserve the tissues when drying could be difficult. Where flies are a problem, squirt formaldehyde into any opening (nasal, eye, ear, mouth, anal) so as to discourage egg-laying. Gasoline may be effective also. Sew the tail incision after inserting a support wire with a cotton body. All ends of wire lengths should be tucked under the cotton of the ventral surface. The use of a heavy-duty needle for sewing will be necessary. Once the body is oriented for drying, sew up the hind legs and across the pelvic region. The flat, case-filled skin requires no pinning during drying.

A skin label of heavy paper stock is tied to the right ankle. This contains all of the necessary field data (sex, reproductive condition, collector, preparator number, locality, field measurements, date). It may be advisable to thread one of the label strings on a needle and pass the string through a portion of the ankle skin before affixing the label. This provides greater security against the label becoming lost.

#### LARGE MAMMAL PREPARATION

If the field measurements, especially for the length of head and body (total length minus tail length) exceed the preparator's ability to make a flat, case-filled skin, which will fit inside the storage trays, an open,

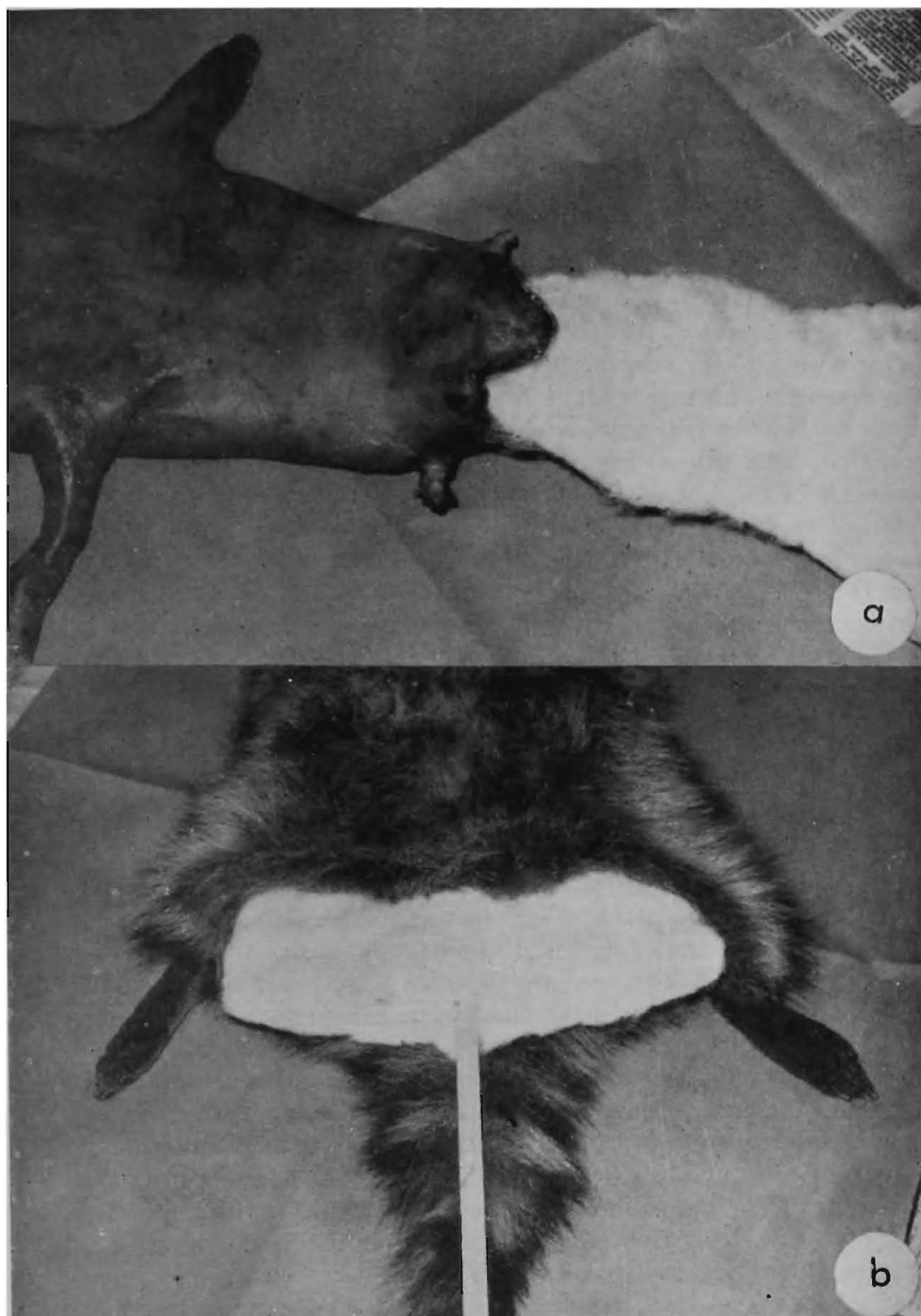


Fig. 8.—The inverted skin (flesh-side showing) is oriented “nose to nose” with the flat body (a) and is worked onto the body so that the fur is right-side-out (b).

flat skin intended for tanning may be prepared in the field. It is the desire of some museum personnel that larger specimens also be prepared dry for study so that the expense and the chemical process of tanning can be avoided. H. H. Genoways and D. A. Schlitter (pers. comm.) related a method that they observed at the Museum Zoologicum Bogoriense, Indonesia. Large tiger skins were stored untanned after apparently being draped, positioned, and dried on large hanger structures.

Anderson (1965), DeBlase and Martin (1981), and Miller (1912) are the primary references for this large mammal preparation. The opening incisions (Fig. 9) for skinning have not changed since Hornaday (1891). The open, flat skin begins with a ventral incision extending from the tip of the tail, up the mid-ventrum (along one side of the anus and external genitalia), to the throat. Each leg receives an incision that cuts from the underside of the foot up the back of each leg until reaching either the "elbow" or knee joints ("hocks-joints" in ungulates). The incision on ungulates proceeds between dew claws to the edge of the hoof on each foot (Fig. 9). This incision continues to the inner side of each leg and upward to the median cut. Extend the ventral incision through the middle of the lower lip (DeBlase and Martin, 1981) or to one of the corners of the mouth (Anderson, 1965). These would be unacceptable for a taxidermy preparation (Anderson, 1965). Avoid cutting through the abdominal wall and do not begin skinning until all incisions are made.

The skin of some mammals is tightly attached to the flesh, while that of others, such as the white-tailed deer, is loose and can be more easily removed. Free the skin from the Achilles tendon and the adjacent portion of the hind leg. As you pull the skin away from the leg, the leg can be more fully flexed to produce enough slack so that the skin can be worked down over the foot. On ungulates, a scalpel handle can be inserted between and around each of the toes to work the skin away up to the last joint. This joint is cut and the terminal phalanx or coffin bone is left with the hoof in the skin, unless this distal bone can be easily removed. The incision on the nonungulate foot should not be extended across the sole (Rowley, 1925). It is advisable to make the incision along its outside edge, avoiding damage to the foot pads. Skin out all of the phalanges of the foot to the base of each claw (Fig. 10a). DeBlase and Martin (1981) leave the foot skin inverted for degreasing, defleshing, and drying. Hornaday (1891) provides skinning instruction for the hands of apes, which includes incisions along the ventral length of the palm and each finger. This is apparently oriented toward taxidermy preparations.

As a taxidermy procedure, Hornaday (1891) leaves all the leg bones of deer and smaller-sized mammals with the dry skin. This practice has

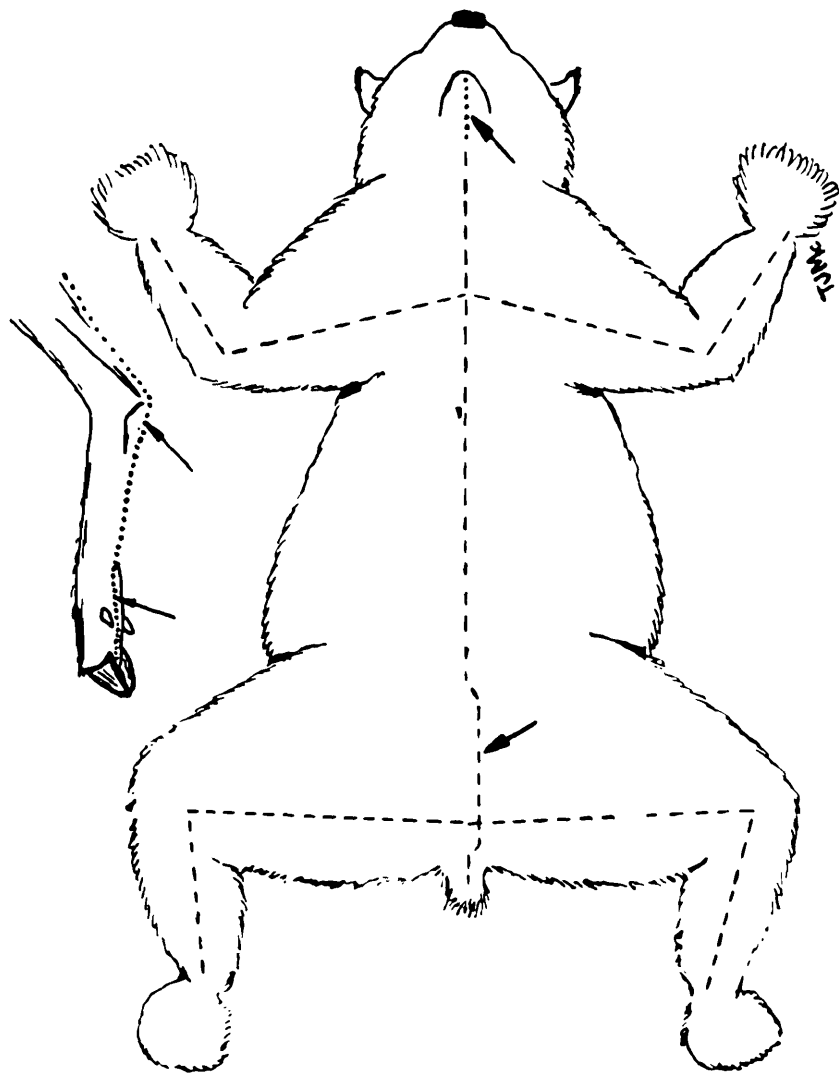


Fig. 9.—Incisions for the preparation of an open, flat skin for tanning. The incision can run through the middle of the lower lip or to one of the corners of the mouth. The smaller illustration demonstrates the incision for an ungulate foot.

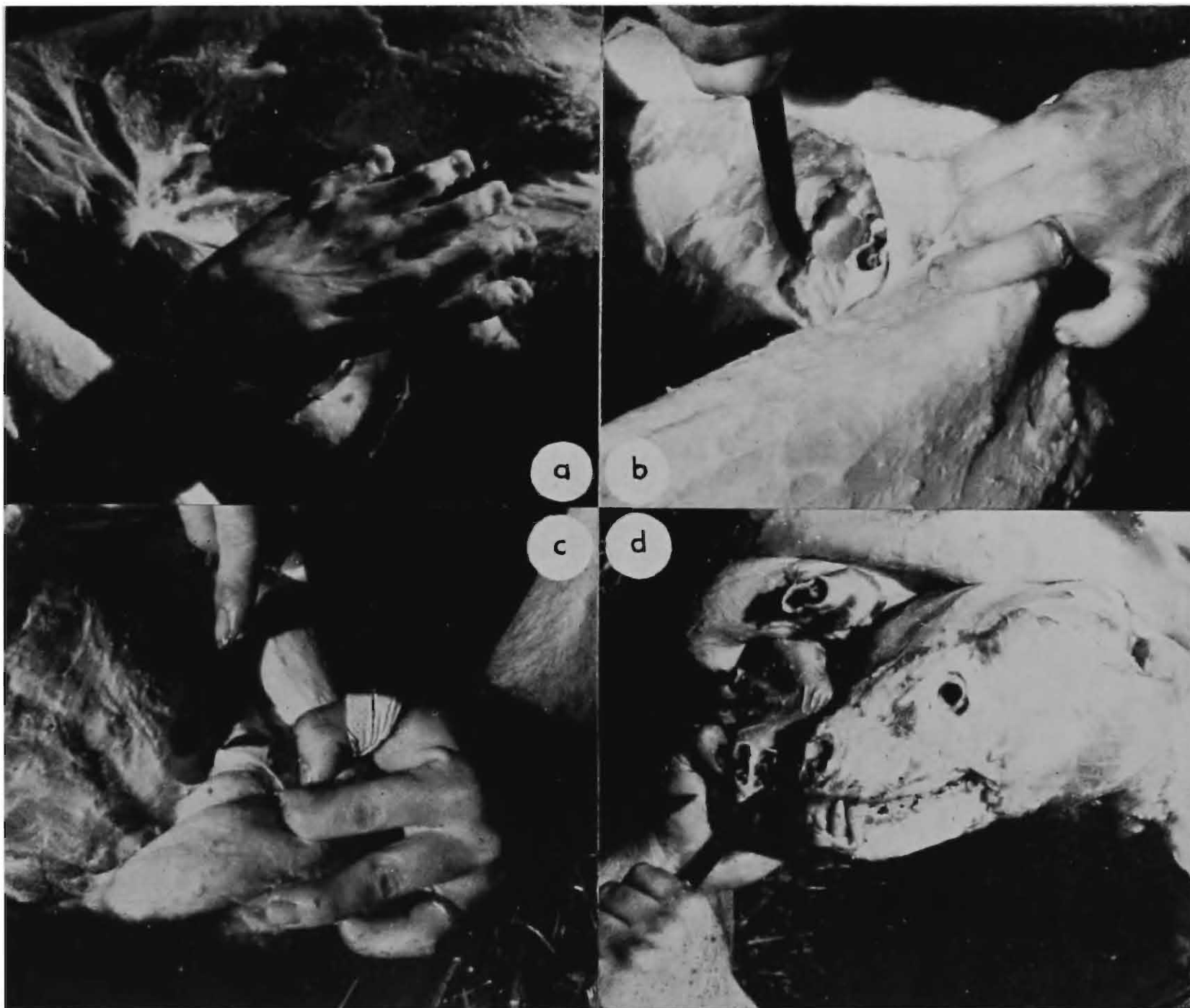


Fig. 10.—Skin on each foot is removed to the claw or hoof (a) ; the ears are severed close to their base on the skull (b) ; the eyelids are cut free without damage (c) ; the skin is removed from the nose with most of the nasal cartilage attached to the skull (d). The specimen is a black bear (*Ursus americanus*).

continued over the years, even when open, flat skins were prepared as study specimens. All bones must be removed in the field to prevent mechanical damage such as tearing of the skin (Fig. 11) before and after tanning.

Skin carefully and remove all of the tail vertebrae. Do not cut the tail if the skeleton is to be collected. Sever the rectum well inside the aperture and work the skin over the rump. If the preparator is able and chooses, the hind legs can be slit so that a strong stick or hooks can be thrust under the tendons of Achilles. The specimen can then be hoisted and hung while the skinning is completed. All possible flesh, fasciae, and fat are separated from the skin. Should bleeding occur, roll the edges of the skin with the hair underneath so that the hair will not become bloody (Anderson, 1965). An old cloth can be used to blot the blood.

The forelegs can be freed of skin in the same manner as the hind legs. Continue to work the skin over the shoulders and neck. If the specimen has no horns or antlers, continue to skin the head, working back the skin as free of fat and connective tissue as possible. Upon reaching the base of the ears, cut these as close as possible to the skull to free them (Fig. 10b). Bleeding may occur after doing this. Blot with a cloth or a small amount of hardwood sawdust or cornmeal. Work the skin over the cheeks and throat. Use care not to cut the eyelid. Insert a finger into the eye socket from the fur side and pull the skin away from the skull, stretching the tissues that hold the eyelids to the skull. Cut these tissues close to the bone and free the lids (Fig. 10c). Continue to cut close to the bone in front of the eyes to avoid cutting through the skin of the antorbital pits (on some artiodactyls). The lower lip is cut along each dentary until the skin is completely freed from the mandible. The upper lip is freed in a similar fashion. With care, the skin can be removed from the rostrum leaving most of the nasal cartilage attached to the skull (Fig. 10d).

A special incision is made on the back of the head and neck to skin a horned or antlered specimen (Fig. 12). A cut is made about midway on the back of the neck and extending to a point above the position of the occipital condyles. A Y-shaped incision results when the neck incision continues to the base of each horn or antler. The skin is cut and wedged away from the base of each structure. It may be convenient to disarticulate the skull from the carcass so that the skin can be worked from the remainder of the head.

The lips must be opened ("pocketed") to prevent loss of hair. Separate the inner mucous membrane up to the bottom where the skin folds inside the mouth cavity. Remove as much muscle as possible without damaging the lips. The ears must be skinned all the way to their tips to separate the ear cartilage from the backside of the ear. This will



Fig. 11.—Example of foot bones that were left attached to a dry skin. The skin is torn at the foot, above the hoof.

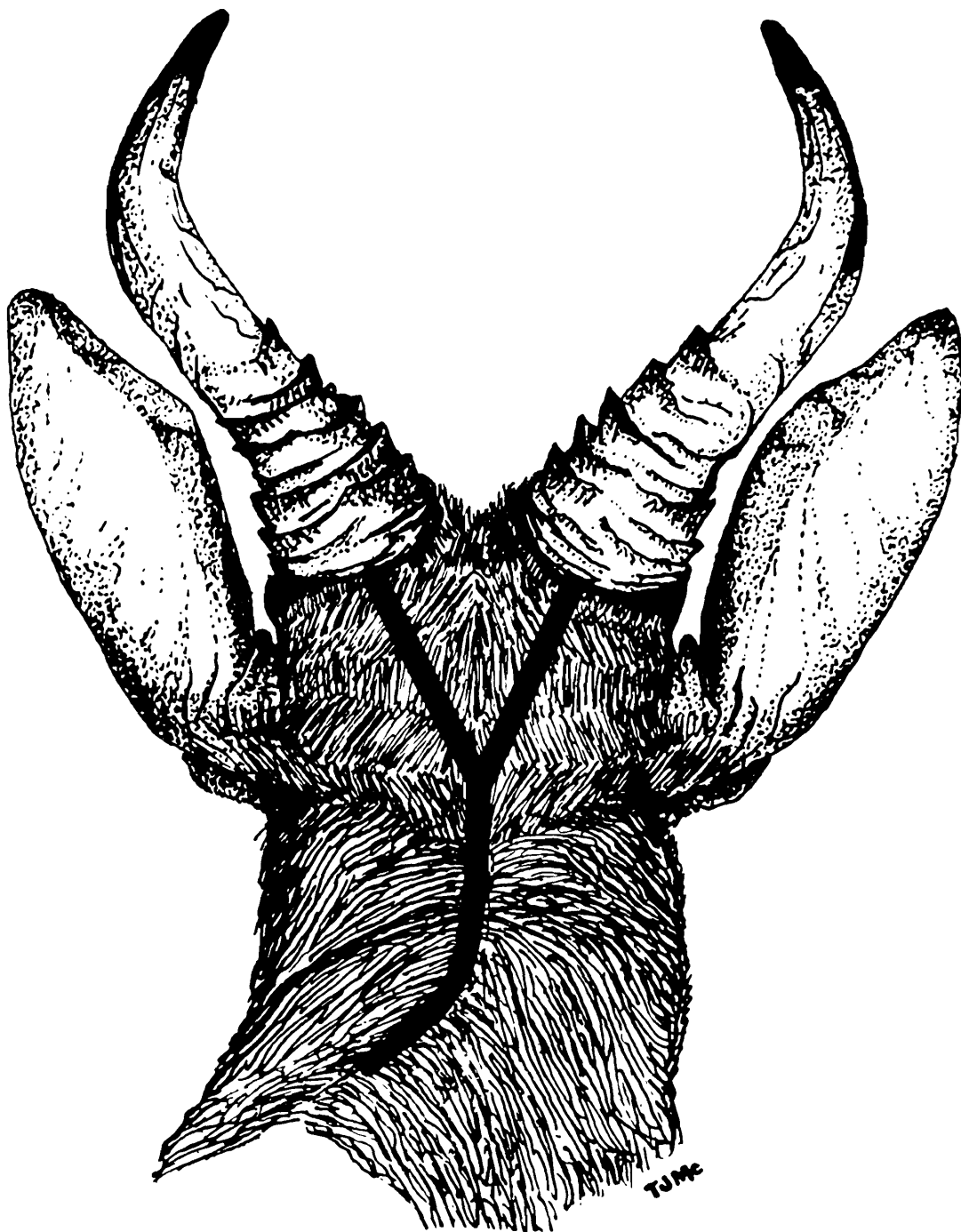


Fig. 12.—An incision (heavy lines) is required on the back of the head and the neck of an antlered or horned specimen so that the skin can be removed from the head completely.



prevent the ear from shrivelling during tanning. Invert the ear as the work proceeds until the ear is inside out. It is usually not necessary to remove the cartilage from the front of the ear unless the skin is fatty or densely haired. The inside of the eyelid needs to be opened to prevent the loss of eyelashes. Small cuts parallel to the edge of the eyelid are made to the back of the eyelids but not through the skin itself. Be careful not to cut into the root papillae of the eyelashes, which appear as a line of small yellow bumps near the rim of the eyelid. Split the nasal cartilage attached to the skin down the middle almost to the skin. This will help to maintain a more "natural" shape to the nose while it dries. If there are large pads of tissue to the inside of the nasal skin and covering the base of the whiskers, carefully remove this tissue so as not to damage the whisker roots (DeBlase and Martin, 1981).

Miller (1912) comments that an elephant, as an example of great size, is best skinned in at least three pieces—head-neck and two longitudinal halves of the body skin.

Hall (1962) stresses that all fat should be scraped off the large skin before drying. If this can be done, then it is not necessary to soak such skins in white gasoline. This also applies to flat, case-filled preparations. Preservatives such as salt, alum, formalin, or borax should not be applied to the skins. Air-drying is the safest approach to avoid colour change of the pelage. When nearly dried, the open, flat skin can be rolled flesh-side out for packing.

Under certain circumstances, as in a hot and humid climate, it may be necessary to salt a skin in order to save it. Anderson (1955) presents a good discussion about salting as a temporary preservative and good poison. Salt is easily obtained for use. Ample amounts of fine salt are spread evenly over the whole flesh surface of the skin soon after skinning. Rub salt into the skin well. The ears, lips, eyelids, feet, and skin-folds are well-salted to get to the bases of the hairs. The skin of the head, neck, and legs is folded over the body skin (flesh to flesh) and rolled up. A major problem with salt is that it readily absorbs moisture from the atmosphere besides from the skin. Consequently, the resulting brine should be removed from the skin surface and the skin resalted.

Clearly record on skin labels and in field notes that the skin was treated with salt. If an insecticide or repellent agent is used on the skin, it should be applied with precautions for the health of the preparator and the skin should be clearly labelled that it has been treated. Following tanning, record the specific tanning process utilised for future reference, should storage deterioration occur.

## SKELETAL PREPARATION AND DRYING

Following removal and the subsequent preparation of a skin, a decision needs to be made about keeping all of the remaining skeleton, a select portion of this or just the skull. Many systematists prefer not to obtain the postcranial elements since their research primarily concerns cranial morphology and pleage characteristics. Additional problems such as storage space, drying time, and protection from insect damage weigh heavily against preparing the entire skeleton. Regardless, an effort should be made to secure at least representative adult skeletons so that this material is available for investigations of comparative anatomy and functional morphology. In a case such as a roadkill, the skeleton may be the only salvageable remains if not badly damaged.

The viscera are excised following the removal of the skin or after the preparation of the study skin. The immediate removal and burial of the viscera away from the work area will reduce the number of flies drawn to the carcass, especially in humid environments. It may be necessary to work under the protection of mosquito netting in order to protect the skeleton from fly larvae infestation during preparation and drying. Of course, the same applies to the skin preparations.

Lucas (1891) provides a thorough account for the preparation of full skeletons. The legs are detached from the carcass and all excess masses of flesh and fat are cut away. Slits between the digits and the lower long bones assist the drying time. Remove the scapulas with the forelimbs. Continue removing muscle from the axial skeleton ; slit and remove the muscle from between the ribs to increase ventilation and reduce the drying time. Skeletons should be more thoroughly roughed out in areas of high humidity (Hall, 1962). It is recommended to skin and remove the extremities completely, which means to the tip of the tail and to the claws or hoofs of the feet. Fig. 13 provides a view of all the roughed skeletal elements of a young North American black bear (*Ursus americanus*).

While roughing the specimen, take care not to remove such bones as the clavicle or patella with the meat. The clavicles are small or minute in the cats and the weasels, for example, and missing in the canids, bears, seals, and most artiodactyls, whereas climbing and burrowing mammals have well-developed clavicles.

Avoid damaging the hyoid apparatus, baculum (if male), epipubic bones in marsupials, tail tip, splint bones, and cheek and pelvic bones in cetaceans (Hall 1962; Lucas, 1891). All of these should be saved and properly tagged. The hyoid bones are located at the base of the tongue so caution must be taken when removing the majority of the tongue mass.

The skull is always disarticulated at the joint between the occipital condyles and the atlas vertebra. The eyes and heavy muscle are removed. An adequate-sized forceps can be forced beneath and behind



Fig. 13.—The roughed skeleton of a black bear (*Ursus americanus*). The mandible normally is not disarticulated from the cranium in the field.

the eye in order to pull it from the socket. Use care when cutting excess muscle so as not to damage any thin skull processes. Sever the esophagus and trachea so that the hyoid apparatus remains attached to the skull. Prolonged gentle boiling to clean skulls (British Museum Natural History, 1968) is not necessary in the field. The mandible is not disarticulated from the cranium in the field. Miller (1912) suggests that the lower incisors of deer are too exposed and should be wrapped with cotton for protection.

The use of a looped or hooked wire or a wooden stick will facilitate the loosening of the brain, which must be removed from the skull (Anonymous, 1911; British Museum (Natural History), 1968; DeBlase and Martin, 1981; Lucas, 1891; Nagorsen and Peterson, 1980). The brain tissue can be scooped out and the skull cavity flushed with water from a large syringe. DeBlase and Martin (1981) and Hall (1962) recommend that the skulls be soaked for 12 hours in cold water to remove blood and loosen the brain. The brains are blown out with water from an atomizer bulb or a large hypodermic syringe fitted with a large blunted needle. This soaking method is not encouraged in humid regions because it is necessary to dry the skulls quickly.

All skeletal material and skins must be thoroughly cleaned and dried in the field to prevent rotting (Anonymous, 1911). Never dry in direct sunlight or direct heat, but in a shaded, safe location. In a humid climate, skulls, skeletons and skins should be dried within an enclosure where a heat source keeps the atmosphere dry and warm. Specimens can also be arranged under a canopy of black plastic sheeting so that solar heat can be generated without exposing these specimens to direct sunlight or heat. Drying will be more even with proper ventilation and rearrangement. The drying heat should not be so intense that flat, case-filled skins will dry unevenly, causing parts of the preparation to warp. This can increase overall the intended height of the specimen and it will be unable to lay flat in a museum storage tray. Partially dried flat, case-filled skins can be layered and spaced within field equipment boxes during the night, slow burning candles are safely positioned inside these boxes so the direct heat of the flames exit from openings between cardboard sheets that are arranged to act as a cover. The candle heat keeps the box warm and dry inside, as opposed to a damp tropical night. Open, flat skins should be layed out in a flesh-side-out manner over a board, a rail, a light frame, or what-ever is available for proper drying. Direct sunlight can fade pelage colour and the direct heat can cause cracking and shrinkage. Do not hang the skin by the nose or unduly stretch during drying.

Hall (1962) and Nagorsen and Peterson (1980) recommend cloth wrapping for skulls to dry within, protected from damp weather and flies. Cloth bags have been used for larger mammal skeletons and skulls under humid tropical situations, where flies can cause great difficulty (personal observations). It is important to keep all bone material dry and free of

maggots and beetle larvae. Maggots will discolour the bone, loosen sutures, and obliterate data on tags (Hall, 1962). Rather than wrap the skull, appendages, and the axial skeleton together (Lucas, 1891), each element has field tags attached with the appropriate field number and identification, and is then stored in a separate cloth bag. These are placed in a shady, breezy location that is out of the reach of scavengers. If the material can be initially dried as mentioned above, the bags will be free of the blood stains that encourage flies to lay eggs. It is important to keep the cloth dry and not in contact with the drying flesh. A complete wire hoop stitched to the inside will keep the bag material taut. The field number can be written on each bag. When thoroughly dried, the skeletal elements can remain within their bags (remove wire loops) and are stored in a dry field locker that is not air tight, but is bug-proof. An air-tight enclosure such as plastic bags can cause mold or the skeletal material to macerate (DeBlase and Martin, 1981). All skeletal material should be periodically investigated for maggots. Heat will force out maggots for removal with a forceps. Never use salt, formalin, large amounts of sawdust, or any poison, such as arsenic, on any skeletal material if this will be subjected to cleaning by carnivorous beetles. Naphthalene or paradichlorobenzene crystals and DDVP (dimethyldichlorovinylphosphate) resin strips in cloth bags can be placed with the skins and skeletal material during storage to discourage mould and beetles.

Nagorsen and Peterson (1980) state that it may be necessary to split the velvet of developing antlers with a knife to facilitate drying. Miller (1912) suggests that antlers or horns be removed from artiodactyl specimens where storage space is a problem. The cranium should not be mutilated in any way.

Skeletal specimens of the size of a large deer can be disjointed to accommodate packing, usually separating the axial skeleton into three portions—neck vertebrae, rib cage and mid-portion of vertebral column, and remainder of vertebral column, pelvic girdle, and tail (Anonymous, 1911 Lucas, 1891). Larger ungulates can be cut up still further by separating the leg bones at each joint and making several sections of the backbone.

The skeleton of cetaceans is all that is usually preserved because of their large size and the difficulty of completely removing the thick layer of blubber from the inner surface of the skin. Wagstaffe and Fidler (1968) suggest fixing a block of skin with blubber; fins and flippers can be pickled.

#### SUMMARY

This article reviews the preparation techniques available from primarily the North American literature. The E. R. Hall preparation principle (1937, 1962) is emphasized for medium-and large-sized mammals

(larger than the squirrel, *Sciurus niger*). The objective of “firm, symmetrical skins free of all fat” is primary. In addition, the preparation of larger specimens must consider the expenses of tanning and storage space, besides the long-term effects that preparation materials, chemicals, and tanning procedures can have on the integrity of scientific study specimens.

Field preparation of flat case skins ranging up to small ungulates and most carnivores, is encouraged as a means of preservation that avoids tanning expenses and permits conventional storage. The depth, width and length of case trays determine the physical constraints of species prepared in this manner. The skinning involves an incision that extends from the hind foot or hoof down the inside of one leg up along the opposite hind leg. The skin is then removed from the carcass without further unnecessary incisions. The resulting skin, which is turned flesh side out, is outlined on a stiff backing such as double-corrugated cardboard. The body outline is cut and a rigid wooden spine is attached to run the total length. This form is wrapped with one layer of non-absorbant, sterile cotton and the skin is drawn over it at the inverted head position. All appendages are supported with monel wire and positioned to accommodate storage space.

Open, flat study skins of the larger carnivores and large ungulates are generally preferred for tanning. Incisions are made along the mid-ventral body, from the tip of the tail to either the jaw or through the middle of the lower lip. Further incisions are extended from the ventral incision along the inside of each leg to the base of the claws or hoofs. Special considerations are directed to the ears, lips, eyelids, and feet. Specific incisions are made in order to remove the skin from a skull with antlers or horns.

All brains, eyes, tongue and excess muscle of the skulls and all viscera and excess muscle of the skeletons need to be removed to insure proper drying in the field. All skin and skeletal preparations are dried in the shade and are protected from fly and beetle damage.

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## REFERENCES

- THE COMMITTEE ON MARINE MAMMALS, AMERICAN SOCIETY OF MAMMALOGISTS. 1961. Standardized methods for measuring and recording data on the smaller cataceans. *J. Mammal.*, **42** : 471-476.
- ANDERSON, R. M. 1965. Methods of collecting and preserving vertebrate animals. *Bull. natn. Mus. Can.*, **69** : 1-199.
- ANDERSON, S. 1961. A new method of preparing lagomorph skins. *J. Mammal.*, **42** : 409-410.
- ANONYMOUS, 1911. Directions for preserving specimens of large mammals. *Mus. Vert. Zool., Univ. California, Berkeley*, 1-7.
- ANONYMOUS, n.d. Directions for preparing skins of large mammals from the size of a wolf upwards. *Am. Mus. nat. Hist., New York*, 1-5.
- BRITISH MUSEUM (Natural History). 1968. *Instructions for collectors, No. 1. Mammals (non-marine) (2nd ed.)* British Museum (Natural History) **665** : 1-55.
- CLARK, J. L. 1937. The preservation of mammal skins in the field. *J. Mammal.*, **18** : 89-92.
- DEBLASE, A. F. and MARTIN, R. E. 1981. *A Manual of Mammalogy with Keys to Families of the World* (2nd ed.) : 1-436, Wm. C. Brown Co., Pub., Iowa.
- DOWNING, S. C. 1945. Color changes in mammal skins during preparation. *J. Mammal.*, **26** : 128-132.
- HALL, E. R. 1937. Deleterious effects of preservatives on study specimens of mammals. *J. Mammal.*, **18** : 359-360.
- HALL, E. R. 1962. Collecting and preparing study specimens of vertebrates. *Misc. Publ. Mus. Nat. Hist., Univ. Kans.*, **30** : 1-46.
- HALL, E. R. 1968. Review : The bats of West Africa. *J. Mammal.*, **49** : 350-351.
- HAWKS, C. A., WILLIAMS, S. L. and GARDNER, J. S. 1984. The care of tanned skins in mammal research collections. *Museology, Texas Tech. Univ.*, **6** : 1-32.

HENDERSON, F. R. 1975. How to skin a coyote ? *Coop. Ext. Serv., Kansas State Univ., Manhattan*, **67** : 1-11.

HORNADAY, W. T. 1891. *Taxidermy and Zoological Collecting*. pp. 1-362, Charles Scribner's Sons, New York.

HOWELL, A. H. 1937. A simple method of saving small mammals in the field. *J. Mammal.*, **18** : 95.

KNUDSEN, J. W. 1966. *Biological Techniques*. pp. 1-525. Harper and Row Publ., New York.

LUCAS, F. A. 1891. Notes on the preparation of rough skeletons. *Smithson. Instn., U.S. natn. Mus., Part C, U.S. Natn. Mus Bull.*, **39** : 1-11.

MILLER, G. S., JR. 1912. Directions for preparing specimens of mammals. *U.S. natn. Mus.*, **39(N)** : 1-16.

NAGORSEN, D. W. and PETERSON, R. L. 1980. Mammal collectors' manual. *Misc. Publs. Life Sci., R. Ont. Mus.*, 1-79.

ROWLEY, J. 1925. *Taxidermy and Museum Exhibition* : 1-331. D. Appleton and Co., New York.

SETZER, H. W. 1968. Directions for preserving mammals for museum study. *U.S. natn. Mus., Smithson. Instn., Inf. Leaf.*, **380** : 1-19.

SWENSON, L. E. 1954. Less bulky mammal study skins. *Colorado-Wyoming Acad. Sci.*, **4** : 61-62.

WAGSTAFFE, R. and FIDLER, J. H. 1968. *The Preservation of Natural History Specimens*. Vol. **2** : 1-404. Philosophical Library, Inc., New York.





## **SKELETAL PREPARATION TECHNIQUES**

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### **INTRODUCTION**

Skeleton is the enduring evidence for the study of relationships among animals. From the characters and the shape of the skeleton a specimen can be identified up to genus or even to species. It serves as a basis for studies of vertebrate relationships, classification and evolution. It helps the palaeontologists to compare the animal remains of the past, which they collect in archeological or geological excavations, with the present day forms. The skeleton is a very important subject to taxidermists too. Without a fair knowledge of it, they can not achieve perfection in the articulation of skeleton and mounting, for museum display.

Skeletal system is divided into two parts : (a) Exoskeleton, consisting of hairs, nails, scales, spines, horns, etc., which are epidermal in origin. These parts are automatically preserved with the proper preservation of skin, for which special techniques are adapted. (b) Endoskeleton, consisting of the bony parts which constitute the frame work of the body and give protection to most of the vital organs, such as brain, heart, lungs, etc.

### **SOURCES OF ACQUISITION**

In the Taxidermy section of the Zoological Survey of India, animals are acquired from different sources.

- (i) Specimens brought by different field parties of the department, making collections.
- (ii) Dead animals from the Zoological Garden, Calcutta.
- (iii) Donation from private parties.
- (iv) Purchase from local market.

India is rich in faunal resources. But in recent years, due to changes in land use, the population of most of the free ranging animals

have reduced. So it is advisable to preserve both the skin and the skeleton of each of the large mammals collected.

### TECHNIQUES

For the preparation of articulated or disarticulated skeleton, the following methods are adapted in the Zoological Survey of India:—

- (i) Hot water maceration technique
- (ii) Burial technique

#### HOT WATER MACERATION TECHNIQUES

Hot water maceration is the easiest and the most popular method for the preparation of ligamentary (Fig. 1a) as well as disarticulated skeletons in the Zoological Survey of India. After taking all the relevant data from the animal, it is skinned first. Then the viscera is removed and the muscles attached to the bones are scraped off as far as possible with the aid of a skinning knife. In all the cases special care is taken not to cut the ligaments and damage the bones. Now the skull is separated from the Atlas vertebra. The brain is removed with the aid of a brain-spoon or a flat curved needle, through the foramen magnum.

If the animal is of the size of an adult bear, or a tiger, it is separated into smaller parts like head, neck, rib-cage, lumber, tail, limbs, etc. In the vertebral column, a brass wire is inserted through the neural canal and is knobbed at both ends.

Now water is boiled in a tub over an electric heater/gas burner. A small quantity of sodium carbonate is added in the water. When the temperature of the water reaches about 40°C, all the bones are dropped in it. The heater is switched off to avoid direct flame to the bones. A stream of water vapour can also be passed over the bones through a pipe. Constant observation is essential because over maceration will loosen the bone-sutures and ligamentous connections. When the flesh on the bones becomes softened, it is removed with a pair of forceps and a scalpel. The skeleton is again kept in hot water tub for a few minutes. The remaining flesh is cleaned with a hard hair brush or soft brass wire brush. When properly cleaned, all the bones are dried. Maceration of bones in water at room temperature also gives a good result. In this case the skeleton is allowed to macerate in running tap water for two or three days. Constant observation is required to prevent the ligaments from disintegrating. It is then kept in lime water (300 gms of calcium hydroxide in 10 litres of water) for another one or two days. Now all the



Fig. 1.—(a) Articulated skeleton of a mammal prepared by Hot Water Maceration Technique (b) Skeleton of a monkey prepared by Burial Technique

flesh is cleaned. The remainder of the procedure is the same as mentioned earlier.

#### BURIAL TECHNIQUE

Burial technique is applied for the preparation of disarticulated skeletons of large mammals such as deer, bear, elephant, tiger, rhinoceros, etc. It is a slow but sure process. In this process the carcass is skinned and the viscera is removed before burial. A trench, depending on the size of the carcass, is dug in a vacant space. The trench should be at least 30 cm larger than the specimen on all sides but the layer of soil above the specimen should be at least 100 cm thick. It is wise to keep a plan of the burial site so that at the time of excavation the skeleton may not be damaged.

Now decomposition sets in. Dermestid beetle larvae, ants, isopods and many other micro-organisms feed on the flesh of the buried animal. Ultimately all flesh is consumed by the above organisms, leaving behind the skeleton. It is observed that the cleaning of the skeleton takes about three months for an animal of the size of a monkey, and about four or five months for an adult tiger or dolphin. This cleaning time varies with the season. During the rainy season it takes less time than in the winter season. After a lapse of the above mentioned period the skeleton is dug out from the trench. Special care is taken while removing the soil from the upper layer.

A dead monkey was buried in the museum campus on August 27, 1982. On November 18, 1982 the skeleton was dug out and washed in tap water to remove the soil attached to the skeleton. It was found that all the parts were nicely cleaned within this period (Fig. 1b).

#### PREPARATION OF SKELETON OF LARGE MAMMALS IN THE FIELD

This method is applied only in the field during the collecting tour. When a large mammal is collected, it is skinned after taking all the measurements and other relevant data for mounting in the laboratory. The carcass is left in the field at some distance from the camp. In no time the vultures flying in the sky will land and attend the carcass. They eat much of the flesh leaving behind the intact skeleton.

Care should be taken to protect the carcass from the attack of other carnivores during the process of exposing it to vultures. When considerably cleaned, the carcass is removed from the open field. All the

bones are dried in the sun and packed for transport to the laboratory for further treatment.

#### DERMESTID BEETLE TECHNIQUE

Cleaning of osteological material by larvae of the dermestid beetle is very popular in western countries. This technique is useful as the skeletal material is cleaned without any manual labour and secondly even very small and delicate skulls can be cleaned without any damage inflicted to them. However, this technique is, at present, not adopted in the Zoological Survey of India as we don't have the infrastructure for maintaining a dermestid beetle colony and secondly this beetle is very harmful to museum exhibits. If once the infection reaches the main collection, the whole collection may be spoiled within no time.

#### DEGREASING METHOD

For small animals special treatment for removal of fat from the skeleton is not required, as during the process of hot water maceration and bleaching of bones, the fat automatically washes away. However, in case of large animals, fat is to be removed before bleaching and this process is known as degreasing. If the bone is not properly degreased, the fat may emit offensive odour, discolour the bones, and may even attract insect pests in course of time.

It is advisable to degrease the skeletons of large mammals including birds and reptiles by keeping them in fat-solvent. In case of long bones, two holes at two ends of the limbs are drilled for easy penetration of solvents inside the bone marrow where plenty of fat is present. The bones are kept in a jar containing carbon tetrachloride. Since carbon tetrachloride is extremely volatile, a little water is poured on the upper surface to check the evaporation as well as to avoid any possible fire. Special precautionary measures are taken while working with carbon tetrachloride because it is harmful both to skin and health. It is advisable to handle the solution after wearing rubber gloves. The bones should remain in the above chemical from a few hours to a few days according to the size of the bones and the amount of fat stored in them.

There are other chemicals too which are fat-solvents. The skeleton may be kept in an air tight container, containing a mixture of liquid benzene and chloroform. This method also gives a good result. The smoking should be avoided during processing. Such degreasing operations should be carried out in a fireproof building as far as possible.

In yet another method, the limb bones of elephants, rhinoceros, camels, etc., are thoroughly dried before the defatting process commence. As stated earlier, such bones are drilled with two holes on either extremity. Petrol is pumped through one of the holes to penetrate inside the marrow and left for a few minutes, then pumped again. Through the hole at the other end, the fat will flow out. When satisfactorily cleaned, the bones are dried in the sun.

#### BLEACHING OF BONES

Bleaching of bones is generally carried out by keeping the bones in hydrogen peroxide in the proportion of one part of hydrogen peroxide and five parts of water. A weak solution of calcium hydroxide or chlorinated water may also serve the purpose. After bleaching and obtaining the desired whiteness, the bones are taken out. The time vary from four to 24 hours depending upon the age and size of the bones. The bones are thoroughly rinsed in running tap water to remove all the residue chemicals, and then dried in the sun. When completely dried, 50 gms of bleached shellac in 500 cc. of 90% ethyl alcohol, or 20 gms of celluloid dissolved in 200 cc of acetone and amyl acetate is sprayed on the skeleton.

#### MOUNTING OF SKELETON

A taxidermist must have a fair knowledge of the habits and habitat of the animal to be mounted. Some photographs in different poses will help a lot in articulating and mounting the skeleton. For hollow mounting of large mammals, the measurements of the dead specimens are taken at different points before skinning, such as the length of head and body, tail, forelimbs, hind-limbs, distance between the two limbs, circumference of the body, height from the ground, etc. These measurements help to determine the length of the main support and to shape the skeleton while mounting.

#### ARTICULATION

Skeleton of small-sized mammals up to the size of a rabbit may be prepared as ligamentary skeleton. But care should be taken during the process of maceration. Bones may be detached if there is over maceration. The detached and disarticulated parts may be fixed to their respective places with adhesive. Stickfast is good for quick setting, whereas araldite is a slow setter but is a strong adhesive.

Preparation of ligamentary skeleton is not possible in case of large mammals. The skeletons are generally prepared as articulated ones. All the cleaned and bleached parts of the skeleton (vertebrae, ribs, pelvic girdle, pectoral girdle, skull, etc.) are serially arranged on a board. In case of any doubt help of a specialist may be sought.

For mounting skeleton of a large mammal (Figs. 2a & b), a brass or galvanised rod of suitable diameter is selected as per measurement. It is then pushed through the entire length of neural canal of the vertebral column. The rod is curved where necessary, to give it a proper shape. The curving should be according to the shape of the animal. The anterior end of the rod is pushed into the skull through the foramen magnum. Lower jaw is plugged with the upper jaw by inserting a brass wire.

For medium-sized mammals the ribs are arranged serially. The head of each rib is tied with the concave facet of the thoracic vertebrae by the help of wire. The ribs are spread and held in position by twisting wire around each rib and in between adjacent ribs. To keep the rib-cage in position, an iron rod of required size is fitted transversely with central rib of each side by drilling holes in them. In case of large mammals, the ribs are arranged around an iron plate (approx 1.5 cm thick) of the size and shape of the rib case, and each one of them is screwed with it from the inner side.

The pelvic girdle is attached to the posterior end of sacrum. Each half of the pelvic girdle is screwed with the sacral vertebrae. Similarly, the scapula of the pectoral girdle is fitted in position on the second thoracic vertebra. For setting the caudal vertebrae, a soft galvanised wire of desired gauge is tapered at one end. The caudal vertebrae are arranged from 1st to the last vertebrae. Then the wire is pushed through their neural canal. The distal end of the wire is plugged and the proximal end is pushed through or plugged with the sacral vertebrae. Bones which do not move freely against each other are wired rigidly, but those which articulate together at a joint are wired in such a way that these can move. A hole is drilled in the head of the femur and another in the acetabulum. A single brass wire is pushed through these holes and bent at both ends to hold the leg in position. The fibula is joined with tibia by screwing on both extremities. Then tibia-fibula is joined with the femur by using a brass wire. Similarly, the head of the humerus is fitted in the glenoid fossa of the pectoral girdle. The radius is screwed with the ulna. The trochlea of humerus is placed on the sigmoid notch and joined with a wire through a hole drilled for the purpose. The front portion of the sternum (Presternum) is tied with the first thoracic vertebra from the ventral side and the posterior end is hanged in position on two wires fixed with the eighth rib of the two sides.



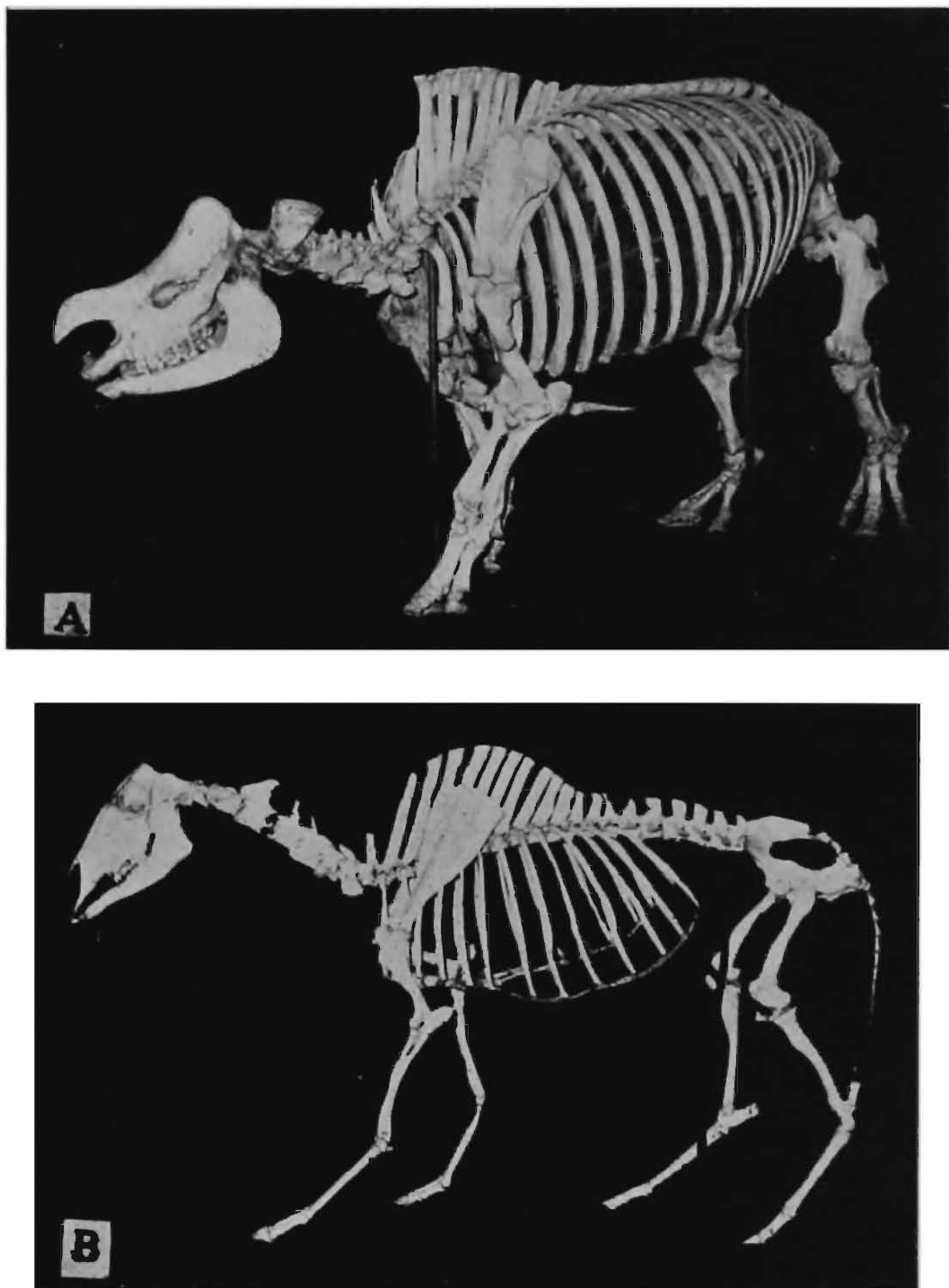


Fig. 2. A, B—Articulated skeleton of large mammals

The carpals, metacarpals, tarsals, metatarsals and phalanges are separately mounted by passing wire through holes made length-wise with a high speed drill. Terminal ends of the wire are fixed with the permanent base by drilling holes in it.

The skeleton is now ready to be transferred and mounted on a permanent base made of teak wood. Dimension of the base-board depends upon the size and shape of the specimen. For holding the articulated skeleton two iron rods of suitable size and thickness are selected. One

end of each rod is threaded so as to fit it on the base with the help of nuts and washers. The tip of the other end is split (2.5 cm to 5 cm in length) by using a hacksaw and the two halves are bend in the shape of a 'Y' for placing the vertebral column on it. Two holes of suitable size are drilled on a wooden platform at appropriate position. The rods are fixed on the platform one in line with the pelvic girdle and another with the axis vertebra (2nd vertebra). The articulated skeleton is now transferred for mounting on the permanent platform. The vertebral column is positioned on the Y-shaped hook of the rods. Broken or disarticulated parts, if any, is glued at its respective place with araldite. After completion of the mounting, white shellac dissolved in rectified spirit is sprayed on the skeleton. Transparent varnish can also be sprayed to make it moisture and dust-proof.

### SUMMARY

The skeleton serves as a basis for studies of vertebrate relationships. It also helps in identification of taxonomic categories. The present paper deals with the techniques of preparation of skeletons. Hot water maceration and burial techniques are used in the Zoological Survey of India. Next follows degreasing and bleaching of bones. The method of preparation of articulated skeletons has also been discussed.

### ACKNOWLEDGEMENTS

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## **SKELETAL PREPARATION TECHNIQUES**

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### **INTRODUCTION**

In museums worldwide, preparation procedures for mammals involve skinning and stuffing study specimens, preserving specimens in formalin, and cleaning skeletal material. The skeletal material is probably the most scientifically valuable part of the specimen. Proper labelling, handling, and cleaning of skeletal parts is the most time-consuming and tedious aspect of specimen preparation. Improper labelling, handling, and cleaning of skeletal material can change a scientifically valuable specimen into a pile of nearly worthless bones.

### **FIELD PROCEDURES**

Proper labelling and handling of skeletal material begins in the field. As soon as the skin is removed from the specimen, the skull and/or skeleton should be tagged. In the case where the only part of the skeletal material to be saved is the skull, the tongue and flesh between the lower jaws should be removed. In animals the size of a rat or larger, the muscle masses on the cheeks and cranium should also be removed. The eyes should be removed, taking care not to damage any of the surrounding bones. The skull is then labelled with a small tag of 100% rag content. On only one side of the tag is written in permanent, black ink the preparator's initials, the preparation number, and the sex of the animal. The tag is then tied by running the string between the lower jaws and tying loosely around one ramus. The string is tied with either a square or an overhand knot, taking care not to tie tightly as there is a danger of breaking the jaws of small, fragile specimens. The loose ends of the string are cut off at approximately two centimetres from the knot (Hall, 1962, Setzer, 1968).

Specimens for which a complete skeleton are to be kept should be eviscerated, taking care not to cut into the sternum or its associated cartilage. Remove as much of the muscle mass as possible being careful not to remove the clavicles or patellas. In some animals the clavicle "floats" in the muscle and must be dissected out and physically tied to the skeleton. Removing the flesh between the ribs also aids in drying. In large specimens it may be necessary to detach the limbs.

The skull in larger animals should be detached and the eyes, major muscles, and tongue removed. In removing the tongue, care must be taken to avoid damaging the hyoid apparatus, a series of small bones connecting the trachea to the skull. The brain should also be removed and the skull tagged.

If the skull was detached, place it within the chest cavity. Fold the legs alongside the body, or, if they were detached, tie them in or alongside the chest cavity. Fold the tail down on itself and tie securely. The skeleton should be tagged in numerous places such as ribs, limbs, and pelvis to assure against a tag being torn off (Lucas, 1891, 1950).

Small mammals, upon being skinned and eviscerated, are tagged and simply folded in half upon themselves. They are loosely wrapped with thread and allowed to dry. Care should be taken not to overwrap a specimen and thus hinder the drying process.

The brains should be removed from all specimens by use of a brain hook or spoon, or by a method commonly referred to as "blowing the brains". With the brain hook, the skull is held so that water from a tap falls into the foramen magnum. The brains are worked out using the hook. When most of the brain is out, the skull is filled with water, shaken, and drained. This is repeated until all the brain is removed (Hildebrand, 1968).

To "blow the brains", a hypodermic needle and syringe are used. The point of the needle is either cut or ground down to a blunt end. The syringe is filled with water and inserted into the brain through the foramen magnum. The brain is gently "scrambled" with the needle and, as the skull is held with the foramen magnum pointed downward, water is injected into the brain cavity. The stream of water forces the brain through the foramen magnum. This is repeated until all of the brain is removed. The skull is then given a final shake to remove any residual water in the brain cavity.

Skulls and skeletons are then hung and dried as quickly as possible to avoid mildew. In the tropics, skulls can be aided in drying by placing them in a jar of denatured alcohol for 24-48 hours. The alcohol displaces the water in the skulls. Directing a blowing fan on the skulls greatly aids in drying.

To avoid damage by animals and having the skeletal material become infested with flies, the skulls should be hung to dry in skull cages (Fig. 1). These cages may be of various sizes and made from various types of screening material. They should be of rigid construction to avoid damaging the skeletal material. They may be constructed of wood and screening, or

of vinyl and plastic screening with a collapsible metal frame. Screening small enough to prevent entrance by flies should be used as much as possible throughout the construction to allow for adequate air circulation. If the skeletal material is to be cleaned by organisms, under no circumstances should the skeletal material be poisoned.

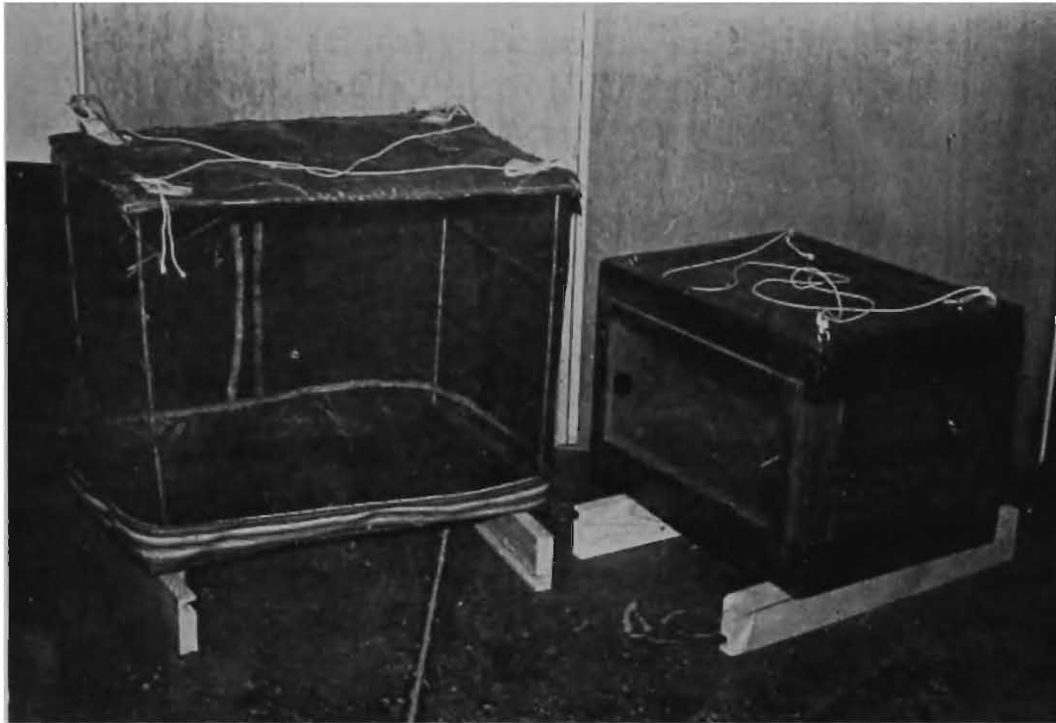


Fig. 1.— Skull drying cases constructed of vinyl, screening, and a collapsible metal rack (left) and a permanent rigid cages constructed of wood and screening. Photo by J. A. Groen/Casne.

When dry, the skeletal material should be properly packed to avoid crushing, and delivered, along with the skins, to the laboratory for further processing. Once catalogued, the skeletal material is then ready to be cleaned.

#### CLEANING TECHNIQUES

To be of any use in a research collection, the skeletal material must be cleaned of all dried tissue. Removal of this tissue is the most time-consuming aspect of the whole collection operation. Throughout the years, various techniques have been developed to aid the preparator in the processing of skeletal material. These techniques, and slight variations, can be broadly categorised into the following : cleaning by maceration; cleaning by heat; cleaning by chemicals; cleaning by digestion or enzymes; cleaning by organisms; degreasing; and final bleaching and washing.

*Cleaning by maceration*

Cleaning by maceration involves immersing the specimen in water until all the flesh decays (Anderson, 1965; Anon., 1958; Hildebrand, 1968; Knudsen, 1966; Thompsett, 1958; Thompson and Robel, 1968; Williams *et al.*, 1977). The bones are placed in a glass, enamel, or earthenware container and covered with water. Metal, wood, etc., must not be present in the maceration container as this will cause discoloration of the bones. The container should be kept in a warm room above 26°C. Complete maceration may take from a few days to months depending on the size of the skeleton. Maceration is complete when the flesh becomes gelatinous and can be scraped off the bones with a fingernail. The bones are then removed, rinsed under running water and scrubbed with a stiff brush to remove any remaining flesh.

Although this method takes little effort on the part of the preparator, the disadvantages far outweigh the benefits. A considerable length of time is needed for its completion and the resulting odour can be most offensive. Maceration causes great disarticulation of the bones including the cranial bones. Unless one wishes a completely disarticulated skeleton, this method is not recommended.

A variation of this method is to bury large skeletons and flippers of cetaceans in sand, thus allowing them to macerate underground (Pycraft, 1925). This method has proven to be quite successful but a tremendous length of time is needed for its completion.

*Cleaning by heat*

Heating or boiling produces clean material in a relatively short time. However, the resulting skeletons are almost completely disarticulated. Various cartilages such as those between the ribs and sternum are destroyed. Bones of immature animals or bones of animals under the size of a dog may warp after boiling.

Skeletons are covered with water and simmered for 1/2 to 2 hours. They are removed from the fire and allowed to cool. The bones must not be cooled rapidly as this may cause cracking of the teeth and long bones. If small holes are drilled into each end of the shaft of the long bones (Fig. 2), the marrow and grease will cook out during heating. Bones are then cleaned with brushes and scrapers under running water. If need be, the bones are resubmerged and heated again until the flesh can be readily removed from the bones (Hildebrand, 1968).

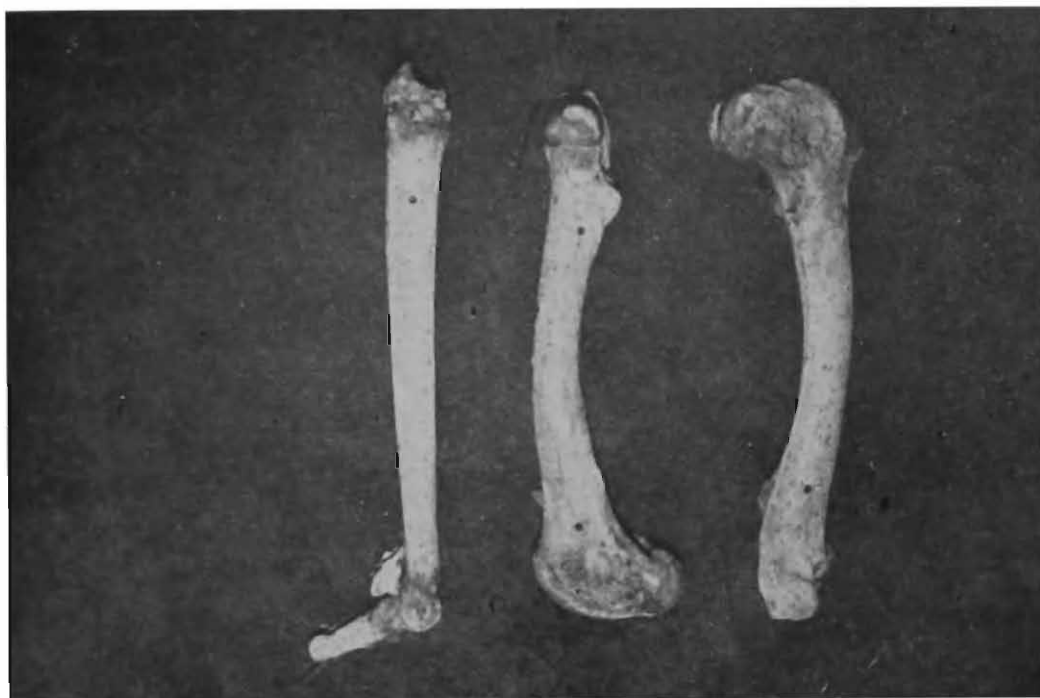


Fig. 2.— Long bone of a white-tailed deer before final cleaning and degreasing showing the small holes drilled into the ends of the bones to aid in removal of the marrow. Photo by J. A. Groen/Casne.

As previously stated, this method is not suggested for specimens under the size of a dog. Most of the teeth of specimens processed in this manner will be loose and require gluing. On specimens with loose sutures in the cranium, there will be a problem with disarticulation of the bones of the skull. An offensive odor may also be produced by this method.

A variation of this method involves cooking the specimens in an autoclave or pressure cooker (Brown and Twigg, 1967). This method has also been refined by the addition of meat tenderizer to the material being cleaned by pressure (Hastings, 1971). The specimens are cooked at a pressure of  $1.1 \text{ kg/cm}^2$  for 5-40 minutes depending upon size. Specimens are removed from the pressure cooker and immediately cleaned under water.

### *Cleaning by chemicals*

Partially due to objectionable results obtained by cleaning skeletons by maceration or by cooking them, numerous chemical means have been tried either alone or in conjunction with heat. These include the use of sodium hypochlorite (commercial bleach, i.e. Clorox, Purex) (Gross and Gross, 1966; Leppart, 1966); ammonium hydroxide (Hoffmeister and Lee, 1963); hydrogen peroxide (Howell, 1919); ammonia, Clorox, and



peroxide (Schmidt, 1966); carbolic or cresylic acid, ammonia, and peroxide (Holden, 1914, 1916); antiformin (Green, 1934); sulphurated potash (de Klerk *et al.*, 1964); sodium perborate (Chapman and Chapman, 1969; Jakway *et al.*, 1970); and potassium carbonate (Iverson and Seabloom, 1963).

Cleaning skeletal material using chemicals involves repeated soaking of the specimens in these solutions anywhere from hours to days. This long exposure to liquids can cause disarticulation of the bones. If left for too long, actual disintegration of the bones begins, resulting in the rounding of bones and a white, chalky powder present on the bones when dried. Many of these chemicals are not only deleterious to the specimens, but can be extremely harmful and possibly fatal to the preparator if used incorrectly.

#### *Cleaning by digestion or enzymes*

Skeletal material has been cleaned using various proteolytic enzymes such as trypsin, papain, or pancreatin (Egerton, 1968 ; Harris, 1959 ; Hildebrand, 1968; Luther, 1949; Sandstrom, 1969). Laundry "presoakers" marketed in the United States under the names of "Biz" and "Axion" have also been successfully used. These laundry products also contain a variety of proteolytic enzymes (Ossian, 1970).

The skeleton is placed into a 0.5-1.0% solution of the enzyme. This solution is then incubated at a constant temperature between 25° and 40°C for 1-24 hours. The time is variable depending upon the size of the specimen, temperature of the solution, and degree to which one wishes to have the muscles dissolved. The specimen is then removed, rinsed under running water, and brushed to remove any remaining tissue.

Williams *et al.* (1977) stated that after an extended time following cleaning by enzymes, material at Carnegie Museum of Natural History showed signs of deterioration and in some cases led to destruction beyond use. It has been suggested that the enzymes continue working inside the bone tissue after the actual cleaning has stopped. I suggest, should this method be employed, that all bones be soaked for a brief period of time in Clorox to "kill" the enzymes and then rinsed well in water. Once again, this method of skeletal preparation produces totally disarticulated skeletons.

#### *Cleaning by organisms*

Various living organisms have been used to do the initial cleaning of skeletal material. These include ants (Crawford and Atkinson, 1975;

Williams *et al.*, 1977), isopods (Bolin, 1935), crayfish (Sealander and Leonard, 1954), clothes moths (Banta, 1961), mealworms (Allen and Neill, 1950), and dermestid beetles (Borell, 1938; Case, 1959; Coleman and Zbijewska, 1968; Hooper, 1950; Laurie and Hill, 1951; McComb, n.d.; Scheffer, 1940; Sommer and Anderson, 1974; Tiemeier, 1940; Williams and Groen, 1980; Williams *et al.*, 1977).

If skeletal material which has been poisoned is to be cleaned, extreme care must be taken that the material be thoroughly washed to remove any trace of the poisoning agent. This material should then be isolated and cleaned by a sub-colony of organisms. Introduction of poisoned material into the main colony can cause sterilisation or even death of the colony.

Ants, which are readily acquired, rapidly and thoroughly clean a skeleton. However, the formic acid which is secreted and deposited on the bones can contribute to the disarticulation of the skeleton. They are, therefore, not recommended.

Under specialised circumstances, one may wish to use isopods (Bolin, 1935) or crayfish (Sealander and Leonard, 1954) to clean skeletal material. Their use is greatly hindered by having to be maintained in an aquatic environment. Introduction of too much skeletal material at one time will cause the flesh to begin rotting before it can be eaten. This in turn pollutes the water and could lead to the demise of the crustaceans. Care must be taken to use only the smaller individuals since skulls may be crushed by the chelae of larger individuals.

Another organism which has been used to clean skeletal material is the larvae of the common clothes moth (Lepidoptera : Tineidae) (Banta 1961). The larvae readily clean both skinned and unskinned material and are quite easy to raise and maintain (Griswold, 1933). These organisms produce a natural webbing which must be carefully removed once the material is cleaned. Clothes moths are extremely hazardous to skins if infestation of the collection occurs. A colony of clothes moths must be strictly monitored and the collection should be fumigated regularly (Williams *et al.*, 1977).

Mealworms (Coleoptera : Tinebrionidae) have successfully been used to clean skulls (Allen and Neill, 1950). Mealworms are easily obtained and take little maintenance (Galtsoff *et al.*, 1937; Peterson, 1964). They are not as likely to cause infestation problems in the collection. They prefer fresh material but care must be taken not to introduce too many fresh skulls as a mildew problem may result which is deleterious to the mealworms. Mealworms are easily contained in metal or plastic buckets to which bran is added to a depth of a few centimetres. Skulls are placed

just under the surface of the bran. A disadvantage to the use of mealworms is that many times the skulls of small mammals are damaged by large mealworms. It is, therefore, recommended that mealworms be used only for larger specimens (Williams *et al.*, 1977).

Probably the most widely used organism to clean skeletal material is the dermestid beetle (Coleoptera : Dermestidae). They readily and successfully clean all sizes of skeletal material, are easily obtained, and with diligence, they are contained and maintained. Cleaning using dermestids is most efficient on medium-to small-sized specimens. There is no warping of bones, loosening of teeth, warping of cartilage, and, if removed at the appropriate time, an articulated skeleton is possible.

Dermestids can be collected from most carcasses or "road kills", particularly if they are partially dried (Hall and Russell, 1933; Hardy, 1945; Hildebrand, 1968. Tiemeier, 1940). Dermestids are small oval beetles varying in length from 2 to 12 mm (Fig. 3). They are usually black or brown above and white below, but many have a characteristic colour pattern. Their antennae are short and clubbed. The larvae are brown above, white below, covered with long hair, and from 2 to 18 mm long. Predominantly it is the larvae which do the eating of the flesh.



Fig. 3. - Skull of mustelid showing proper tag labelling and dermestid larvae and adults. Photo by V. Abromitis.

The colony should be housed in metal or glass containers varying in size from coffee cans to walk-in environmental chambers (Fig. 4) in which temperature and humidity are automatically controlled (Williams and Groen, 1980). For small colonies, coffee cans, 4-liter glass jars, aquaria,



Fig. 4.- Environmental chamber at CMNH showing the use of egg cartons and the control panel monitors temperature and humidity levels. Photo by V. Abromitis.

metal ice chests, or old deep freezers are suitable for maintaining and confining the colony (Borell, 1938, Gennaro and Salb, 1972; Hardy, 1945; Hildebrand, 1968; Laurie and Hill, 1951; Sommer and Anderson, 1974; Vorhies, 1948). Due to the damage inflicted on skins by dermestids by a possible infestation, the colony should ideally be housed in a separate building from the collection. If this is not feasible, they can be housed in containers in a well-sealed separate room as far from the collection as possible. Careful monitoring is needed to prevent their escape. A 3-cm-wide layer of petroleum jelly or grease smeared at the top of the rearing containers will retard the beetles' escape. All rearing containers should be fitted with a lid of screening to provide ventilation and prevent escape of the beetles.

A layer of cotton, newspaper, or corrugated cardboard to a depth of 3 cm should be placed at the bottom of the container. This is to allow a safe place for the larvae to pupate. Tagged specimens in open containers are then placed on top. A variety of containers can be used depending on the size of the specimen. Cardboard trays or boxes, egg cartons, mesh or

wire trays, match boxes, or paper cups secured to a base, make inexpensive and suitable containers (Coleman and Zbijewska, 1968; Hall and Russell, 1933; Hardy, 1945; Hildebrand, 1968; Scheffer, 1940; Sommer and Anderson, 1974). Separate containers for each specimen are needed as the "bugs" tend to move the specimens around while cleaning.

Ideally the dermestid colony should be kept at an even temperature between 24° and 28°C. Some moisture is needed but care must be taken to avoid excess which could lead to mould and mildew and infestations of mites or spiders (Doetschman, 1947; Galtsoff *et al.*, 1937; Hardy, 1945; Tiemeier, 1940). It is a must that the colony be kept in darkness, the only light being that which is needed by the preparator to add new material or remove cleaned material from the colony (Roth and Willis, 1950).

Dermestids must not be maintained on a diet of lean, very dry meat. Some material with meat laced with fat must be added to encourage egg laying and normal growth of larvae and adults (Russell, 1947).

When the skull and/or skeletal material is cleaned of flesh, it should be removed from the colony immediately to prevent eating of the ligaments by the beetles thus resulting in disarticulated skeletons. In specimens to be used for exhibits, the eating of articulations of bones by the beetles can be slowed by painting the joints with a 50% solution of formalin (Sommer and Anderson, 1974). To avoid eating of paper tags by the beetles, these, too, can be treated with a formalin solution (Williams *et al.*, 1977).

Dermestids can be enticed to clean material which has been left for years or skeletal material which has been preserved in alcohol by repeatedly washing the material in ammonia and water for 2—3 days (Case, 1959; de la Torre, 1951). The beetles may be further enticed by painting the skulls with cod liver oil before introduction into the colony (Hooper, 1956).

Once the cleaned material is removed from the colony, it is fumigated to kill larvae or adults which may be hidden inside skeletal parts. This is necessary to prevent infestation of the collection (Williams *et al.*, 1977). The material is then ready for degreasing, final washing, and bleaching.

#### DEGREASING, WASHING AND BLEACHING

Certain specimens, especially those with large bones, need to be degreased. Numerous apparati and solvents have been used.

Bones to be degreased should have a small hole drilled into each end of the long bones (Fig. 2). One should first try soaking the bones for

24-48 hours in a 50% ammonia solution. After soaking, a stream of air is directed into one of the holes forcing the marrow out of the other. The bones are washed with water and thoroughly air dried.

Should an ammonia soaking be insufficient, organic solvents are used to remove the grease. Solvents used are carbon tetrachloride ( $\text{CCl}_4$ ), ethylene trichloride ( $\text{C}_2\text{HCl}_3$ ), and methylene chloride ( $\text{CH}_2\text{Cl}_2$ ). All produce vapors which are toxic (Hildebrand, 1968; McComb, n. d.; Schmidt, 1966). Specimens are placed in covered glass jars containing the solvent and allowed to soak for 1-2 weeks. At the end of this time, the specimens should be free of grease, removed from the solvent, and allowed to air dry. Any bones floating in the solution at the end of the soaking time need further degreasing.

This method may be facilitated with the addition of heat. Because of lethal vapours, special containers must be constructed to contain the vapours produced by boiling the solvent. Degreasing apparatus described by Hildebrand (1968) and Sherman (1925) use carbon tetrachloride as the solvent. With the addition of heat, the time required in the solvent is reduced to 4-6 hours. Due to its expense, the carbon tetrachloride should be reclaimed by distillation.

Material which does not need degreasing is placed in individual glass vials or jars. They are soaked for 12-24 hours in a 25% solution of household ammonia. This soaking loosens any remaining tissue and also helps to whiten the skulls. After soaking, the material is rinsed in water and any remaining tissue is hand-cleaned. If further bleaching is desired, the material may be soaked for 30 seconds to 1 minute in a 50% solution of Clorox. Skulls should be well washed in water and allowed to air dry (Borell, 1938; Hall and Russell, 1933; Hardy, 1945; Hildebrand, 1968; Laurie and Hill, 1951).

#### LABELLING AND REASSOCIATION WITH SKIN

Once completely dried, the skeletal material is numbered. All bones should be labelled with permanent black ink. Bones should be labelled with the collection initials, collection catalogue number, and sex, if the size of the bone permits (Fig. 5). At the minimum, the collection acronym and the catalogue number should be on the bone (Williams *et al*, 1977). Skulls should be labelled with the collection acronym, collection catalogue number, and sex (Fig. 6). Labels should be placed on the left side of the braincase and readable from the left side. Lower jaws should have both mandibles labelled. All labelling must be legible and accurate.

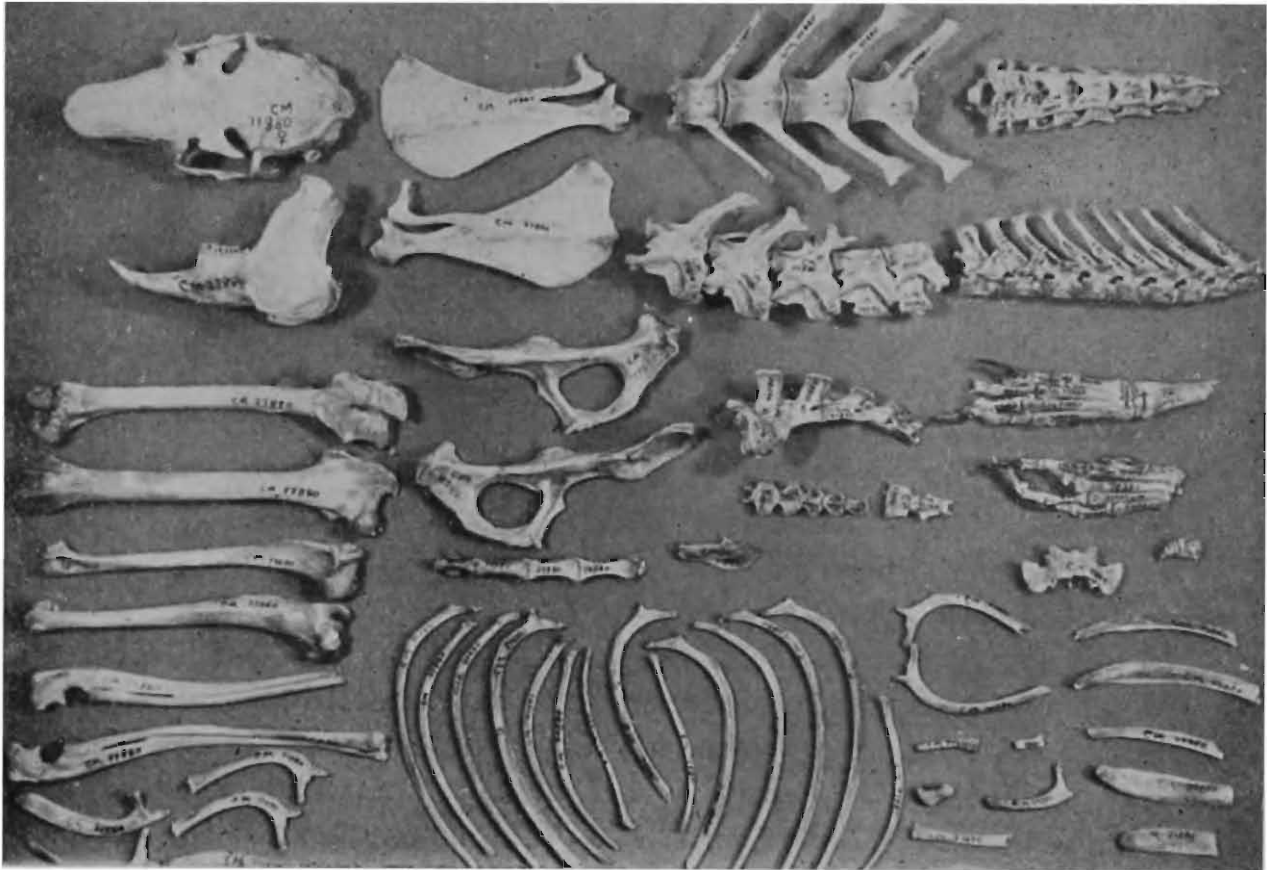


Fig. 5.— Rabbit skeleton showing proper numbering of all bones. Photo by J. A. Groen/Casne.

The skeletal material is then placed in appropriate containers along with a label which includes all catalogue data. It is then reassociated with its corresponding skin to await further organisation and installation.

### SUMMARY

Skeletal parts of a specimen are a major component in the scientific value of that specimen. Proper labelling and handling of the skeletal parts begin in the field. Fast, complete, and protective drying methods must be employed to avoid damage by moulds, insects, and other pests.

The major time spent in skeletal preparation involves cleaning the dried tissue from the specimens. A variety of methods have been used. Opinion varies as to the best method, whether it be cleaning by heat, maceration, chemical means, or various insects and invertebrates.

Following the initial cleaning, hand scraping and washing of the skeletal parts are employed to remove stains and any remaining tissue. Degreasing procedures, especially for specimens having large bones, are initiated at this time. Washings with solutions of ammonium hydroxide, hydrogen peroxide, enzymes, or Clorox bleach remove any final tissue and stains.

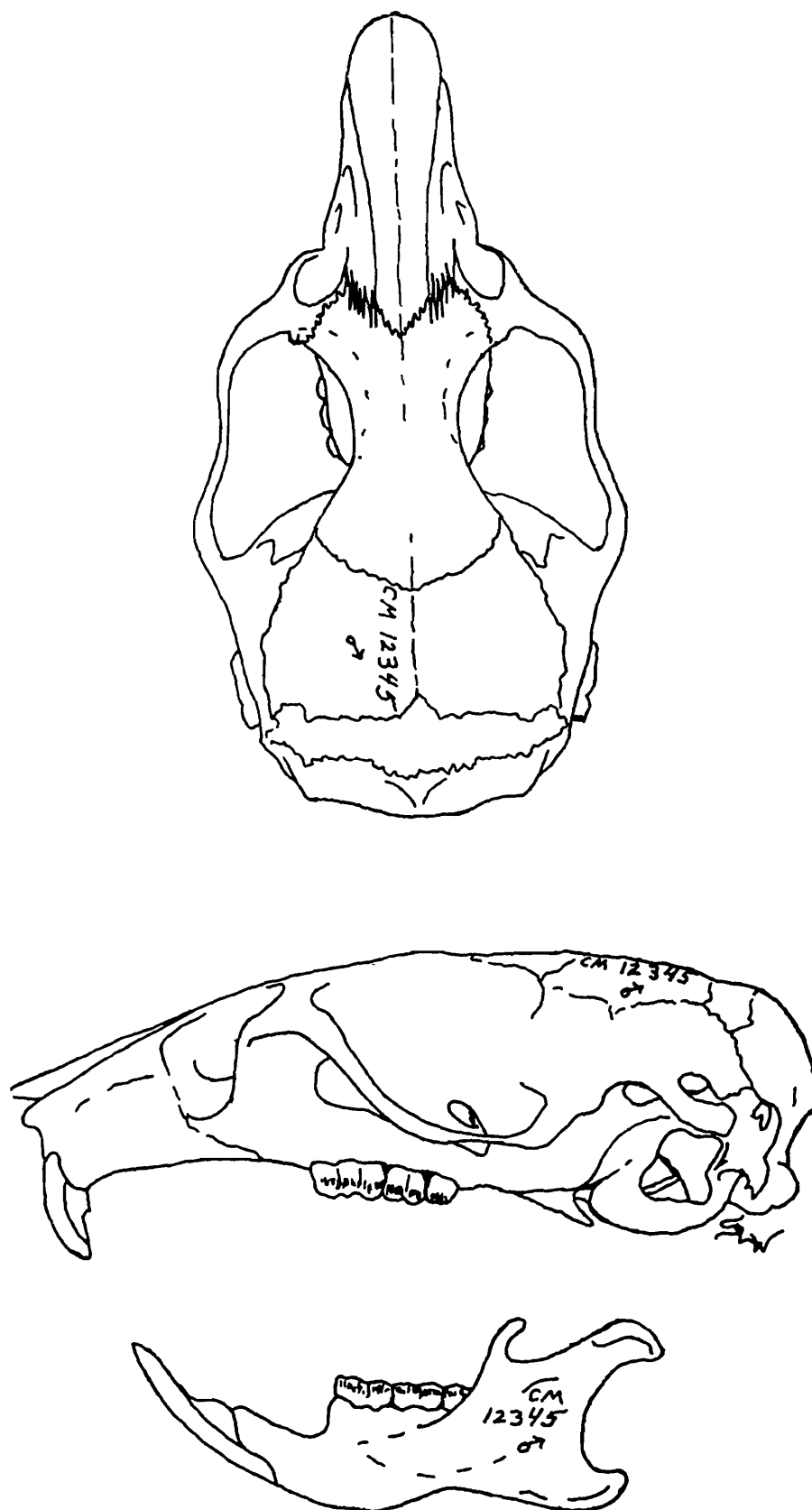


Fig. 6.— Proper labelling of skulls (Annotated drawing from an original by S. L. Williams).



When completely cleaned, the skeletal material must be dried, numbered with permanent black ink to prevent loss of parts, placed in appropriate containers, and reassociated with the corresponding skin.

#### REFERENCES

- ALLEN, E. R. and NEILL, W. T. 1950. Cleaning mammal skeletons with meal worms. *J. Mammal.*, **31** : 464.
- ANDERSON, R. M. 1965. Methods of collecting and preserving vertebrate animals. *Bull. natn. Mus. Can.*, 69 : viii+1799.
- ANONYMOUS. 1958. How to make skeletons. *Turtox Serv. Leafs.*, **9** : 1-4.
- BANTA, B. H. 1961. The use of clothes moth larvae (Lepidoptera : Tineidae) to prepare osteological specimens, with an annotated bibliography on the use of other arthropods for vertebrate skeletal preparation. *Wasmann J. Biol.*, **19** : 265-267.
- BOLIN, R. L. 1935. A method for preparing skeletons of small vertebrates. *Science*, **82** : 446.
- BORELL, A. E. 1938. Cleaning small collections of skulls and skeletons with dermestid beetles. *J. Mammal.*, **19** : 102-103.
- BROWN, J. C. and TWIGG, G. J. 1967. The rapid cleaning of bones in quantity. *J. Zool., Lond.*, **153** : 566-567.
- CASE, L. D. 1959. Preparing mummified specimens for cleaning by dermestid beetles. *J. Mammal.*, **40** : 620.
- CHAPMAN, D. I. and CHAPMAN, N. 1969. The use of sodium perborate tetrahydrate ( $\text{NaBO}_3 \cdot 4\text{H}_2\text{O}$ ) in the preparation of mammalian skeletons. *J. Zool., Lond.* **159** : 522-523.
- COLEMAN, E. J. and ZBIJEWSKA, J. R. 1968. Defleshing of skulls by beetles. *Turtox News*, **46** : 204-205.
- CRAWFORD, R. L. and ATKINSON, J. B. 1975. Fire ants used in skeletal preparations. *Fla. Ent.*, **58** : 8.
- DOETSCHMAN, W. H. 1947. An acarian infestation of dermestid larvae. *J. Mammal.*, **28** : 299.

- EGERTON, C. P. 1968. Method for the preparation and preservation of articulated skeletons. *Turtox News*, **46** : 156-157.
- GATTISOFF, P. S., LUTZ, F. E., WELSH, P. S. and NEEDHAM J. G. (eds.). 1937. *Culture methods for invertebrate animals*. xxxii+1-590, Comstock Publ. Co., Ithaca, New York.
- GENNARO, A. L. and SALB, T. J. 1972. An outdoor enclosure for dermestid defleshing operations. *Swest. Nat.*, **17** : 95-96.
- GREEN, H. L. H. H. 1934. A rapid method of preparing clean bone specimens from fresh or fixed material. *Anat. Rec.*, **61** : 1-3.
- GRISWOLD, G. H. 1933. Fish meal as a food for clothes moths. *J. Econ. Ent.*, **26** : 720-722.
- GROSS, J. E. and GROSS, B. L. 1966. Jackrabbit humeri cleaned with Clorox. *J. Wildl. Mgmt.*, **30** : 212.
- HALL, E. R. 1962. Collecting and preparing study specimens of vertebrates. *Misc. Publs. Mus. Nat. Hist., Univ. Kans.*, **30** : 1-46.
- HALL, E. R. and RUSSELL, W. C. 1933. Dermestid beetles as an aid in cleaning bones. *J. Mammal.*, **14** : 372-374.
- HARDY, R. 1945. Dermestid beetles for cleaning skulls and skeletons in small quantities. *Turtox News*, **23** : 69-70.
- HARRIS, R. H. 1959. Small vertebrate skeletons. *Mus. J.*, **58** : 223-224.
- HASTINGS, S. 1971. A new skull-cleaning method. *Bull. Ga. Acad. Sci.*, **29** : 102-103.
- HILDEBRAND, M. 1968. *Anatomical preparations*. viii+1-100, Univ. California Press, Berkeley, California.
- HOFFMEISTER, D. F. and LEE, M. R. 1963. Cleaning mammalian skulls with ammonia hydroxide. *J. Mammal.*, **44** : 283-284.
- HOLDEN, F. H. 1914. A method of cleaning skulls and disarticulated skeletons. *Condor*, **16** : 239-241.
- HOLDEN, F. H. 1916. Cleaning skulls and skeletons : a supplementary note. *Condor*, **18** : 231.
- HOPPER, E. T. 1950. Use of dermestid beetles instead of cooking pots. *J. Mammal.*, **31** : 100-102.

- HOPPER, E. T. 1956. Selection of fats by dermestid beetles, Dermestidae. *J. Mammal.*, **37** : 125-126.
- HOWELL, A. B. 1919. An easy method of cleaning skulls. *J. Mammal.*, **1** : 40-41.
- IVERSON, S. L. and SEABLOOM, R. W. 1963. A rapid method for cleaning small mammal skulls. *Proc. N. Dak. Acad. Sci.*, **17** : 101-103.
- JAKWAY, G. E., RASKIN, W. and TYLE, T. 1970. Sodium perborate process for preparation of skeletons. *Turtlox News*, **48** : 65-67.
- DE KLERK, W. A., ABRAMS, L. and PRETORIUS, L. S. 1964. Assembling avian and small animal skeletons by using a chemical aid. *Jl. S. Arf. Vet. Med. Ass.*, **35** : 89-91.
- KNUDSEN, J. W. 1966. *Biological techniques. Collecting, preserving, and illustrating plants and animals.* xi+1-525, Harper and Row, New York.
- LAURIE, E. M. O. and HILL, J. E. 1951. Use of dermestid beetles for cleaning mammalian skeletons. *Mus. J.*, **51** : 206-207.
- LEPPART, G. 1966. Preparing mammal skulls for study. *N. Dak. Outdoors*, **28** : 16-17.
- LUCAS, F. A. 1891. Notes on the preparation of rough skeletons. *Bull. U. S. natn. Mus.*, **39** (C) : 1-11.
- LUCAS, F. A. 1950. The preparation of rough skeletons. *Sci. Guide Am. Mus. nat. Hist.*, **59** : 1-20.
- LUTHER, P. G. 1949. Enzymatic maceration of skeletons. *Proc. Linn. Soc. Lond.*, **161** : 146-147.
- MCCOMB, N. W. n.d. Preparing skeletons using demestid beetles. 1-7, Svc. Leaf., Connecticut Valley Biol. Supply Co., Inc. Southamton, Massachusetts.
- OSSIAN, C. R. 1970. Preparation of disarticulated skeletons using enzyme-based laundry "pre-soakers" *Copeia*, **1** : 199-200.
- PETERSON, A. 1964. *Entomological techniques.* v+1-435, Edwards Brothers, Inc., Ann Arbor, Michigan.

- PYCRAFT, W. P. 1925. On the preparation of large skeletons, and flippers of Cetaceans. *Mus. J.*, **24** : 276-279.
- ROTH, L. M. and WILLIS, E. R. 1950. The oviposition of *Dermestes ater* Degeer, with notes on bionomics under laboratory conditions. *Am. Midl. Nat.*, **44** : 427-447.
- RUSSELL, W. C. 1947. Biology of the dermestid beetle with reference to skull cleaning. *J. Mammal.*, **28** : 284-287.
- SANDSTROM, B. 1969. Enzymatic maceration of delicate bone and small skeletons. *Acta Anat.*, **74** : 487-488.
- SCHEFFER, V. B. 1940. A tip on cleaning mammal skulls with the aid of dermestid beetles. *Murrelet.*, **21** : 10.
- SCHMIDT, D. M. 1966. *How to prepare skeletons*. 1-8, Ward's Curric. Aid, Ward's Nat. Sci. Est., Rochester, New York.
- SEALANDER, J. A. and LEONARD, R. G. 1954. Use of crayfish for cleaning skeletal material. *J. Mammal.*, **35** : 428-429.
- SETZER, H. W. 1968. Directions for preserving mammals for museum study. *Smithson. Instn. Inf. Leaflet.*, **380** : 1-18.
- SHERMAN, H. B. 1925. A degreasing apparatus. *J. Mammal.*, **6** : 182-184.
- SOMMER, H. G. and ANDERSON, S. 1974. Cleaning skeletons with dermestid beetles — two refinements in the method. *Curator*, **17** : 290-298.
- THOMPSETT, D. H. 1958. The preparation of skeletons. *Mus. J.*, **57** : 282-287.
- THOMPSON, M. P. and ROBEL, R. J. 1968. Skeletal measurements and maceration techniques for aging bobwhite quail. *J. Wildl. Mgmt.*, **32** : 247-255.
- TIEMEIER, O. W. 1940. The dermestid method of cleaning skeletons. *Bull. Univ. Kans. Sci.*, **26** : 377-383.
- De LA TORRE, L. 1951. A method for cleaning skulls of specimens preserved in alcohol. *J. Mammal.*, **32** : 231-232.

- VORHIES, C. T. 1948. A chest for dermestid cleaning of skulls. *J. Mammal.*, **29** : 188-189.
- WILLIAMS, S. L. and GROEN, J. A. 1980. Vertebrate preparation—Recent vertebrates. *Carnegie Mag.*, **59** (10) : 30-32.
- WILLIAMS, S. L., LAUBACH, R. and GENOWAYS, H. H. 1977. A guide to the management of Recent mammal collections. *Spec. Publs. Carnegie Mus. Nat. Hist.*, **4** : 1-105.

#### DISCUSSION

- Q. What is your opinion about using enzymes like papain and pancreatin for skeletal preparation ?
- A. Bones cleaned with enzymes, after a number of years, tend to become brittle. In cases of extreme grease we use it only with large specimens. If it is used, the cleaned material must be soaked in a solution of Clorox to kill the enzymatic activity.
- Q. Can sex be determined on the basis of skeleton ?
- A. In some cases careful examination of the pelvic girdle may be used to determine sex. In some species that exhibit marked sexual dimorphism, adults may be differentiated on size.

## **MOUNTING AND DISPLAY OF MAMMALS**

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### **INTRODUCTION**

Little is known about the origin of stuffing or mounting of animals either for decorative pieces or for scientific purposes. Although it is well known that the ancients knew the art of preparing animal skins for their personal use but the techniques remained unknown to the scientific world. The Egyptians and Mexicans had further improved the techniques of tanning the skins as well as embalming the bodies of their dead and of other small animals. They are presumed to be the first 'animal preservers' or taxidermists.

The term taxidermy is derived from Greek and its literal meaning is 'arrangement of skin'. The Dutch were probably the first to have used this art for commercial purposes and in the early part of the sixteenth century began their trade of stuffed birds with other countries, but the techniques for mounting of mammals remained obscure for quite some time. Thus it may be surmised that the art of taxidermy gained momentum during the last three or four hundred years. But this art still needs further improvements particularly in respect of minimising the sweating or fat-burns of the treated skins.

For a successful taxidermist, knowledge of comparative morphology, particularly of skeletal and muscular system of the animal concerned is essential. Such knowledge helps him to acquire a clear insight for the normal and natural posture of the animals with which he is dealing. Besides, an idea of their habits and habitats are equally indispensable to enable him in planning, sketching, and modelling the exhibits to give a tinge of natural posture. Thus the modern taxidermy technique is more of a combined skill of a carpenter, a modeller, an artist, and a scientist.

The present contribution deals with the techniques adopted for collecting, mounting, and display of mammals in the Zoological Galleries of the Indian Museum, Calcutta.

### *Collection of specimens*

Several methods are used for collection of the mammalian specimens, such as netting, trapping, shooting with firearms and sometimes by poisoning the quarry through the use of baits. The methods may differ from place to place, animal to animal and often from time to time. Firearms of varying bores are generally used to collect medium and large-sized mammals for use in the galleries of the Indian Museum. However, the task of a taxidermist begins with the death of his quarry. The colour of the soft parts, namely, nose, iris, pupil, etc., as well as the sex of the concerned animal are recorded for future reference.

### *Measurements*

Necessary measurements are recorded carefully before the decomposition of the carcass begins. Mammals which exclusively feed on vegetation or on insects decompose more quickly than the carnivores. Small mammals like shrew, rat, squirrel, hare, etc., are measured as follows : from snout to anus, length of tail, from anus to the tip excluding the hairs of tail-tip, girth of body at two places i.e. on the chest and the abdomen, length of limbs (but in study skins only the length of hind foot excluding the claws), length of ear from intertragal notch to tip of the ear, distance between the inner border of the forelimb (from the head of the humerus) to the hindlimb (to the head of the femur), preferably over a rough sketch of the animal. Similarly, in case of medium and large-sized mammals, the total length from occipital region to the tip of the tail, length from the apex of the throat to the insertion of the tail, circumference of chest and groin regions, girth of the neck at three different places, namely, anterior, middle and posterior parts of the neck in deer and bovids, the distance between the inner borders of fore and hind limbs, height at the shoulder as well as other details of the measurements are recorded over a sketch of the animal concerned (Figs. 1a and 1b).

### *Skinning*

Small mammals, like a squirrel, is placed on its back and an incision made along the middle of the belly from the vent proceeding upwards to the sternum (Fig. 2a). The body is released from the skin without leaving any flesh upon it as far as practicable. The entire body is extracted carefully through this belly incision by disarticulating the hip joints and the leg muscles from the pelvis. The tail is skinned a little up and with the help of a crowder the tail skin of the dorsal surface is loosened, subsequently the entire tail is pulled out from the sheath of the skin by a few jerks. The attachment of tail-flesh with the sheath of

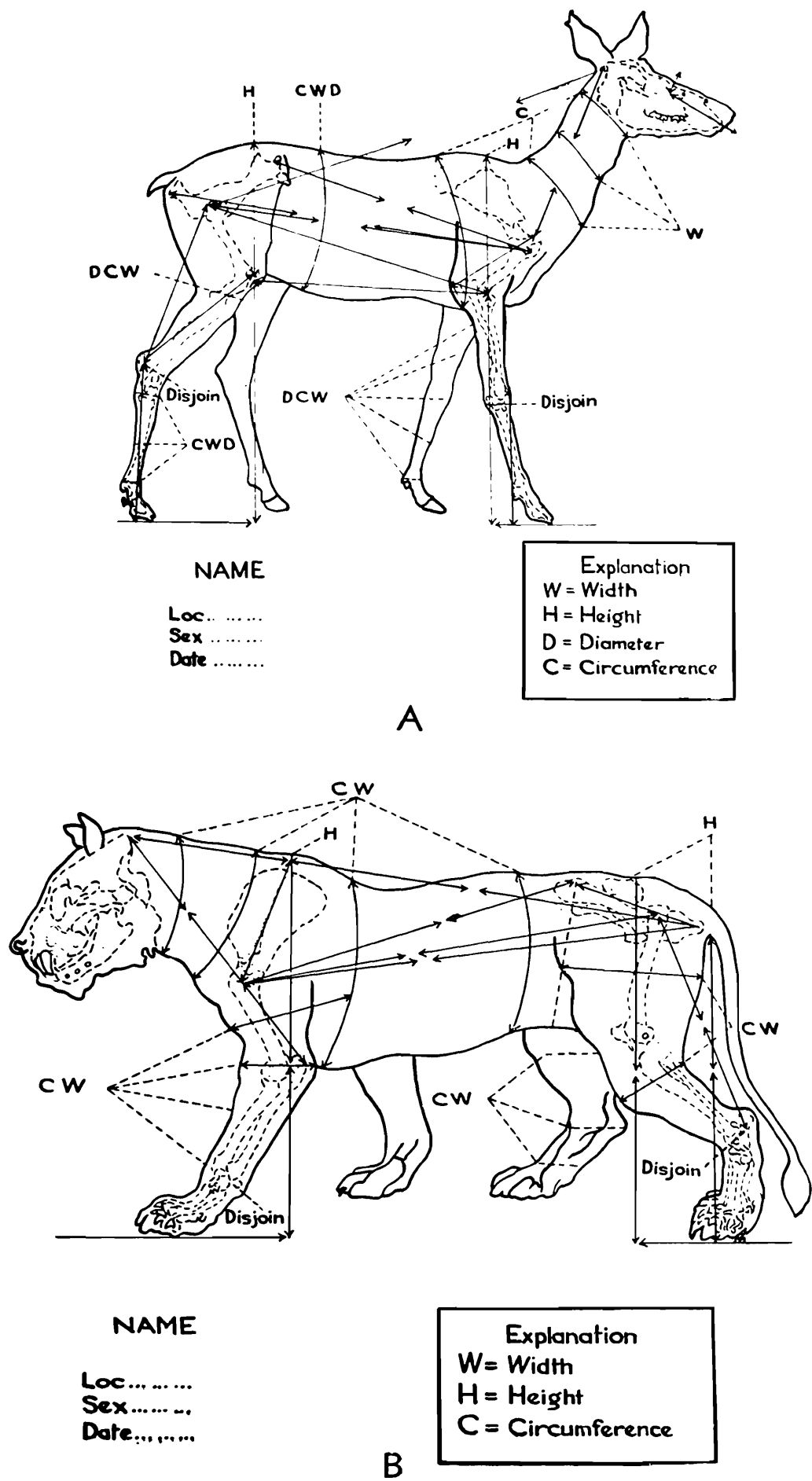


Fig. 1—(a) Lateral view of specimen of an Artiodactyl, showing the body-measurements to be taken before skinning.

(b) Lateral view of specimen of a Carnivore, showing body-measurements to be taken before skinning.



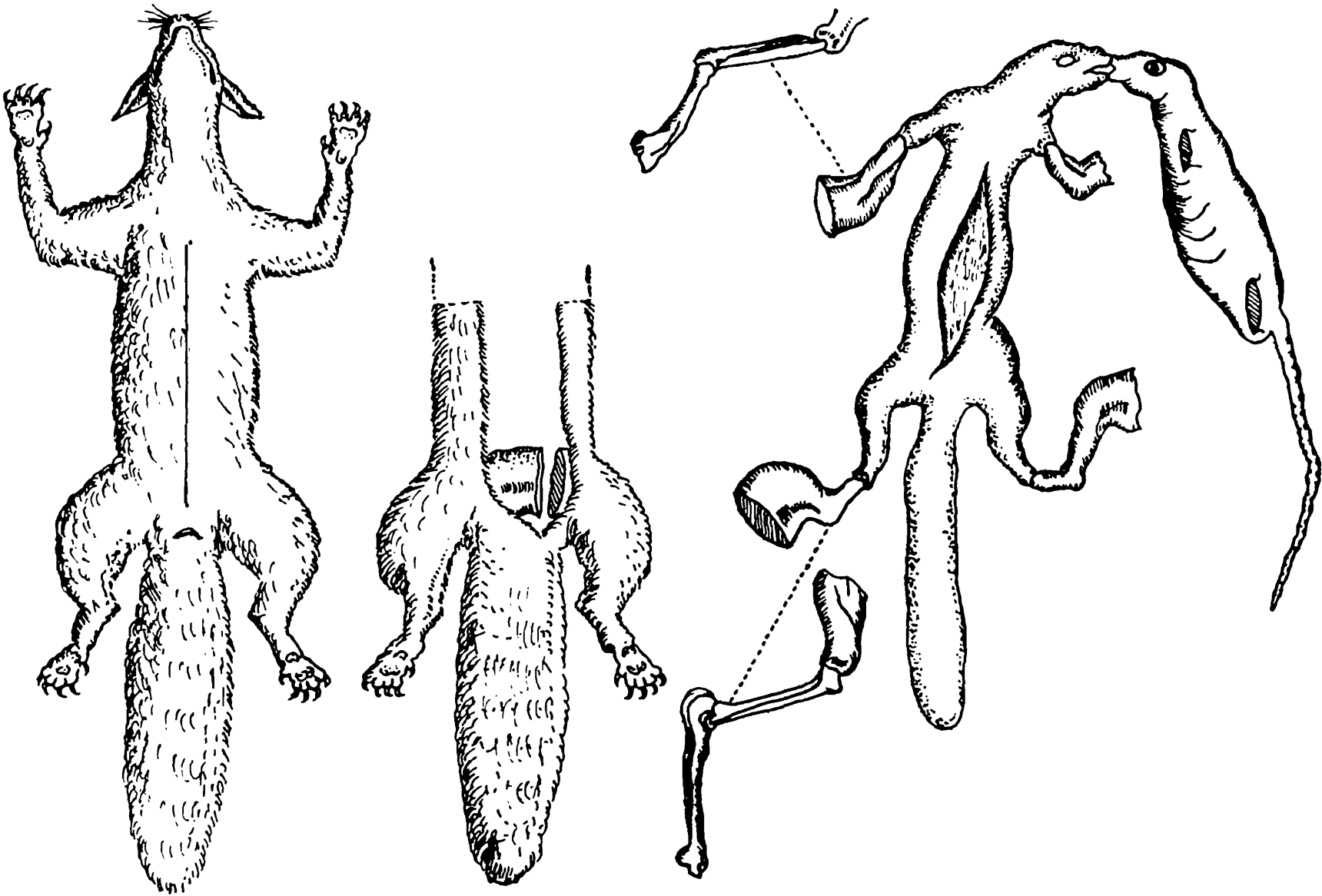


Fig. 2—(a) Skinning process of a small mammal like a squirrel.

skin is comparatively more firm at certain points in some animals. In such a condition, the concerned portion of the tail is incisioned ventrally and skinned off. With the release of the tail-skin the posterior part of the body becomes free from the skin. Similarly, the anterior part of the body is skinned and the forelimbs are detached from the shoulder joints. The entire skin is turned inside out to sever the ears, eye-lids and nose close to the skull with utmost care, without damaging the skin around the head region. By this time the entire body is free from the inverted skin except the skull still attached at the lips. At this stage the body is detached from the skull along with the atlas. The ear is opened up as far as workable to remove the cartilage from the ear-skin, further the flesh from the sides of the face, as well as the eyes from the orbits and cartilage of the nostrils are also removed. The brain from the cranium is scooped out through the foramen magnum and the cranium is washed with saturated borax solution. The flesh from the limb-bones is removed and further the soles of the limbs are split open to clear the flesh as far as practicable. The inverted bag-like skin, commonly called the 'round-type skin' is attached to the skull and limb-bones including the claws.

The medium-sized mammals like, large bats, primates, mouse deer, other small deer, and antelopes are skinned by means of the full-length dorsal incision from the back of the head to the tip of the tail. The legs are completely turned inside out up to the soles or hooves of the fore and hind-limbs, during skinning. In horned or antlered animals, the back of the head is given a prominent Y-shaped incision. Each arm of the 'Y' during skinning leads to the base of the horn or antler and the skin around it is detached along the rim of the circumference.

Flat-type skins have generally been used in the preparation of museum exhibits for animals like large cats, other carnivores, deer, yak, elephant, etc. For this type of skin, like the small mammals, the carcass of the animal (Fig. 3) is placed upon its back and an incision is made on the skin of the belly in a straight median line through the under lip to the tail-tip. This is followed by four cross cuts from the median line along the inside of the limbs down to the toes and the body is skinned out by stripping cautiously around the head region. The skin is made entirely free from the body except the soles or hooves, which remain intact with the skin. The cartilage of each ear is separated from the outer skin of the ear. In the case of a stag or horned animal the antlers or horns are severed before laying down the carcass for skinning. This method was only used for the hollow mounting of the stag. Otherwise horned or antlered animals are skinned by giving the "Y" cut at the back of the head like that of the method mentioned under the full-length dorsal incision type. Sometimes the antlers or horns are kept with the skin by cutting a portion of the parietal.

*Preparation of skin for mounting*

The skin of small mammals may be treated either with borax, alum-borax, or arsenical paste. The skin with fur may be soaked well for about two hours in saturated solution of borax agitating the skin periodically to facilitate complete saturation. Subsequently the treated skin is hung in the shade to drain out the solution. At times the wet treated skin may even be dusted with dry borax to make it fluffy for immediate mounting. The skins treated in borax solution often adversely effect the fur, particularly the milky white fur which may turn to creamy in due course.

The skin with fat is rubbed thoroughly on the flesh-side with alum-borax paste (Appendix I) as a 'cure' and such cured skins may be used for mounting.

The use of arsenical paste (Appendix I) has been found quite satisfactory for the skins like that of a rabbit (i.e. thin skin) as it keeps the skin moist during the mounting process. Further, it is a perfect dryer of animal tissues as well as protects the exhibit from the insect pests. The arsenical paste has certain disadvantages like "sweating of skin", deposition of matallic arsenic while drying, giving off poisonous dust when thoroughly dry or poisonous fumes when hot. These properties of the arsenical paste may at times be hazardous to the health of the user. But inspite of its ill effect, the paste has been quite popular in our taxidermic works both in the laboratory and in the field. It is easy to prepare, use and store it. It is applied on the flesh-side of the skin with a brush.

Both the full-length dorsal incision-type and the flat-type of skins are cleaned and washed in water before stretching them on the floor, keeping the flesh-side at the top. The top skin is dressed with common salt, borax, carbolic acid, and water (Appendix I). While dressing the skin due care is taken that no part of it escapes proper application of the dressing mixture, particularly on those portion where the skin is thick, such as around the lips, eyes, ears, as well as in the folds of the skin. The skin of poorly dressed portion will "sweat" and the hairs will come off from such places in due course. The flesh-side of the dressed skin is scrapped each day for a period of two to three hours and the dressing mixture is rubbed again and again after each scrapping. The treatment may be continued for about a week or more, depending upon the condition of the skin. Thus the treatment will eliminate the fats and any other undesirable tissues, making the skin thin and soft. When the skin appears to be workable it is thoroughly washed to remove all possible traces of the dressing mixture, particularly salt. After washing, the dressed skin is transferred to alum-bath i.e. in a mixture of alum, potassium nitrate, potassium dichromate, and water (Appendix I) for at least two weeks. Such treatment will enable the preservative to penetrate through the skin deeply and fixing

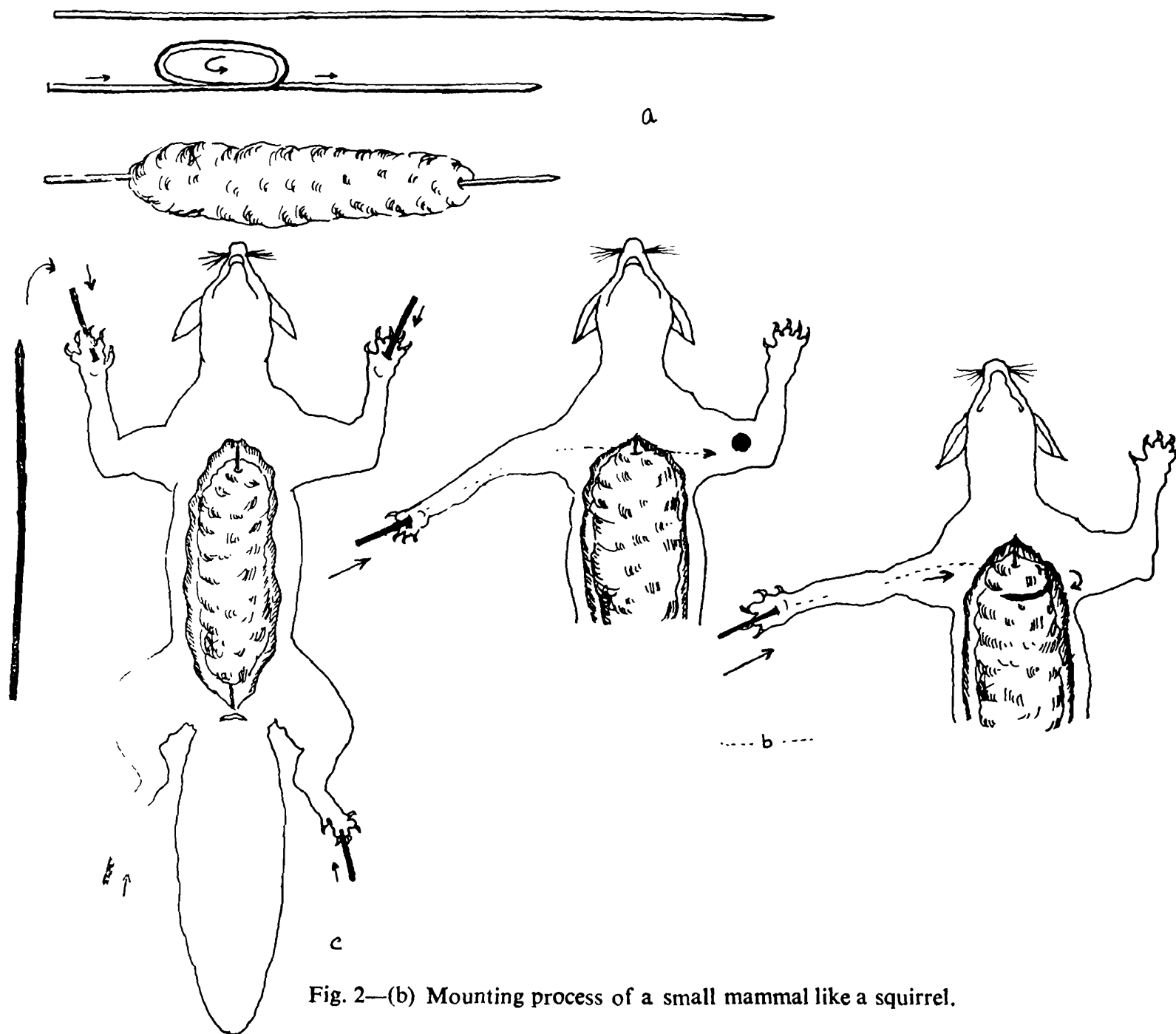


Fig. 2—(b) Mounting process of a small mammal like a squirrel.

the hairs in an admirable manner. It is desirable to examine the skin at regular intervals of 24 to 48 hours during the course of the alum-bath, to work on it, if necessary. Finally the treated skin may be used in wet condition for immediate mounting or it may be dried in open airy shed for its use in due course.

### *Mounting*

A small mammal like a squirrel is normally mounted with a round-type of treated skin along with skull and complete bones of limbs including claws. The artificial body is made in parts on the five galvanised wire pieces of suitable gauge and size, depending upon the measurements, with the help of any of the modelling material (eg. clay, plaster of Paris, papier-mache compound), tow, and cotton. In case of a long-eared animal like rabbit or hare, a thin zinc sheet is used to substitute the ear cartilage. Five pieces of wires, one for each limb and one for the central body are made pointed at one end (Fig. 2b). The size of each wire may be about 12 cm more than the actual measurements. The length of the wire for the central body should be for the total length of head, body and tail together, whereas for the fore-limbs from the toe to the shoulder and for the hind-limbs from the toe to the pelvis joints. Initially the skull is patched up by any one of the modelling material to replace the flesh which has already been removed from the cheeks, the chin, the top of the head including the ears, eye region and the cartilage of the nose. The skull after such patching is inserted back to the skin and the correct placement of it is ensured. Then the pointed end of each leg-wire is thrust through the pads of palms and soles of the fore and hind limbs, respectively, traversing the limb bones. The leg-skin is turned inside out, down to the toes for attaching each leg-wire to the respective limb bone and stuffing each with tow and cotton to replace the leg muscles which has already been cleaned earlier. The body is roughly made on the central body-wire, preferably with one loop upon the wire to keep the body in position or it may be done even on a straight body-wire, depending upon the skill of the taxidermist. The pointed end of the body-wire is pushed through the foramen magnum to come out on the cranium of the skull and the opposite blunt end up to the tail-tip. The exposed wire on the skull is turned upwards to keep the head in position during the mounting. Now the pointed limb-wires of each limb is thrust through the artificial body at the position corresponding to the shoulder and pelvis joints according to measurement, to appear on the opposite side of the body. These pointed ends of each limb-wire are turned like a hook and the wire is pulled back through the palm and sole regions to fix each stuffed limb to the body. Any space on the entire body including the neck and tail regions is stuffed with appropriate material either tow or cotton, or even both, to give a proper shape to the animal. Stitch the belly incision from the vent to the chest and complete the palms and soles by any modelling material to replace the

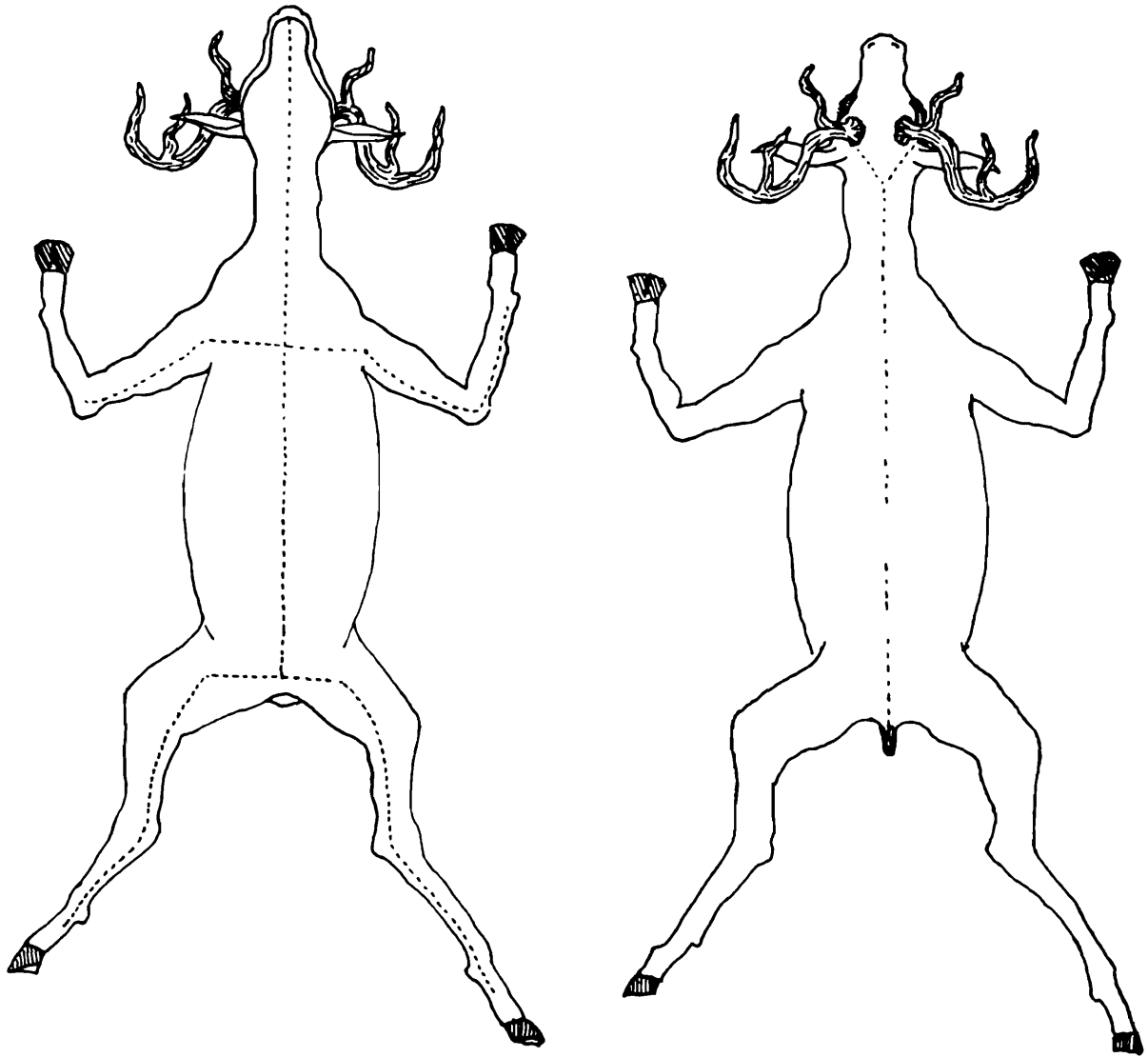


Fig. 3—Skinning process (flat-type) of Chital, *Axis axis*.

removed flesh from these regions. Finally, the desired posture to the body including the proper shape to limbs is given. Now it is fixed on a temporary mounting board or perch by inserting the exposed limb-wires in the holes previously made on them, and each wire is turned back under the board or the perch to keep the animal in position. The claws are arranged and duly pinned on the board or perch for the desired position. The head region is also attended, and with the help of insect pins the respective positions of lips, nose, and ears are arranged. The tail and body hairs are combed and allowed to dry in a shed. After complete drying of the exhibit the exposed skull-wire is cut off. The skin of the eye region is softened by cotton soaked in saturated solution of borax. The eye socket is filled up with modelling material, the artificial eye is placed over it and the eye-lids are shaped properly. The eye-lids, lips, and nose region are waxed and retouched before it is displayed. For medium and large-sized mammals, a treated flat-type skin is generally mounted over a mannikin. A mannikin may be prepared, based on measurements, by any one or a combination of materials like, jute,

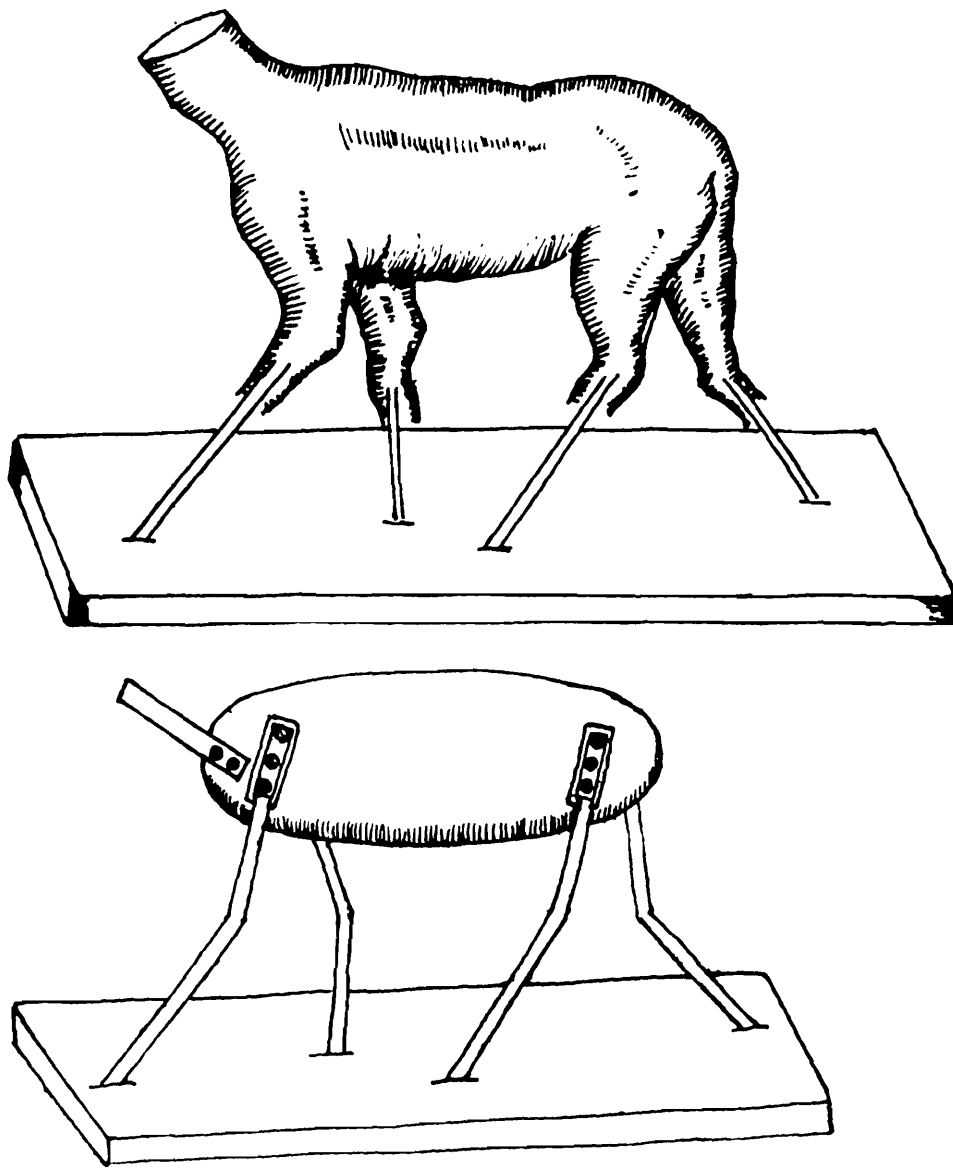


Fig. 4—Mounting process of medium-sized mammal of the size of a Chital, *Axis axis*.

clay, plaster of Paris, rough frame-work of wood and wire-mesh. In recent years it has been found that a much stronger and lighter hollow structure of papiermache can accomplish this work in a much efficient manner. This method was adopted for some of the exhibits in the Zoological Galleries of the Indian Museum, Calcutta, during 1962 to 1968. During this period several specimens of Yak (*Bos grunniens*) and Chital (*Axis axis*) were mounted and a Chital habitat case was introduced in the gallery. The techniques used for the hollow mounting of animals are briefly discussed with special reference to Chital.

A clay model of Chital was constructed with the help of a wooden plank, primarily cut into oval shape, about 80 cm long, 30 cm wide and 2.5 cm thick. It was used as a backbone in the centre of the model which supported four iron rods as limbs and two wooden strips for the neck. The iron rod of 12 mm in diameter was used for limbs. The length of each

limb-rod was 120 cm, approximately 30 cm longer than the actual measurement of the legs (i.e. the length from toe to either the shoulder or pelvis joints). One end of each rod, approximately 20 cm in length, was beaten flat and drilled with three holes to screw it on the central body plank. The other ends of these rods, nearly 10 cm long were threaded to screw the “nuts” on the mounting board. Each rod was bend at three places according to the desired position of the legs. Subsequently four wooden strips (each being 30 cm long, 5 cm wide and 5 cm thick) were fixed, two on each side of the central body plank in the corresponding position of the scapula and the pelvis over which the flat ends of the fore and hind limb-rods were screwed. Two wooden strips (each being 30 cm long, 5 wide and 2.5 cm thick), one on each side of the body plank were nailed at an angle of the desired posture of the neck. This frame was fixed on the mounting board with the help of four pairs of nuts and metallic washers. Four nuts, one in each limb-rod was screwed up to the anterior end of the threading and each nut was succeeded by a metallic washer. The frame was erected on the mounting board by inserting the limb-rods in corresponding holes, previously made on the mounting board according to the position of the legs. The remaining exposed portion of each threaded-rod under the mounting board was secured by placing the metallic washer first and then screwing the nuts tightly in each limb-rod. The model of Chital was then completed by using jute and modelling-clay, approximately 5-10 cm smaller than the measurement of the skin, but true to the desired posture (Fig. 4). Through this clay model, eight pieces of mould were obtained. One pair for neck, one pair each for the anterior and posterior parts of the body, one piece from the junction of the neck and chest to the middle of the belly and the other from the middle of the belly to the groin region (Fig. 5). The material used for the mould was plaster of Paris and cement in the ratio of three to one (3 : 1), to avoid any breakage of mould during handling. The wall of the mould was about 5 cm thick. The clay model was covered in parts by a total of eight pieces. After proper setting up of the plaster-cement mould, all the eight pieces were detached from the model and allowed to dry for about a week. The duration of drying vary with the season. The model was dismantled and the limb-rods along with the respective wooden strips were unscrewed from the body plank. The nuts were also unscrewed from the mounting board for their future use in the cast.

A layer of papier-mache compound (Appendix II), about one centimetre thick, was given in each piece of moulds. This layer was superceeded by chickenwire duly cut to the shape of each piece of mould over which another layer of papier-mache compound of the same thickness was given to strengthen each of the casts. Afterwards each piece was covered with a sheet of blotting paper over which dry sand was put as weight by filling the cavity of the cast to maintain the proper shape of the



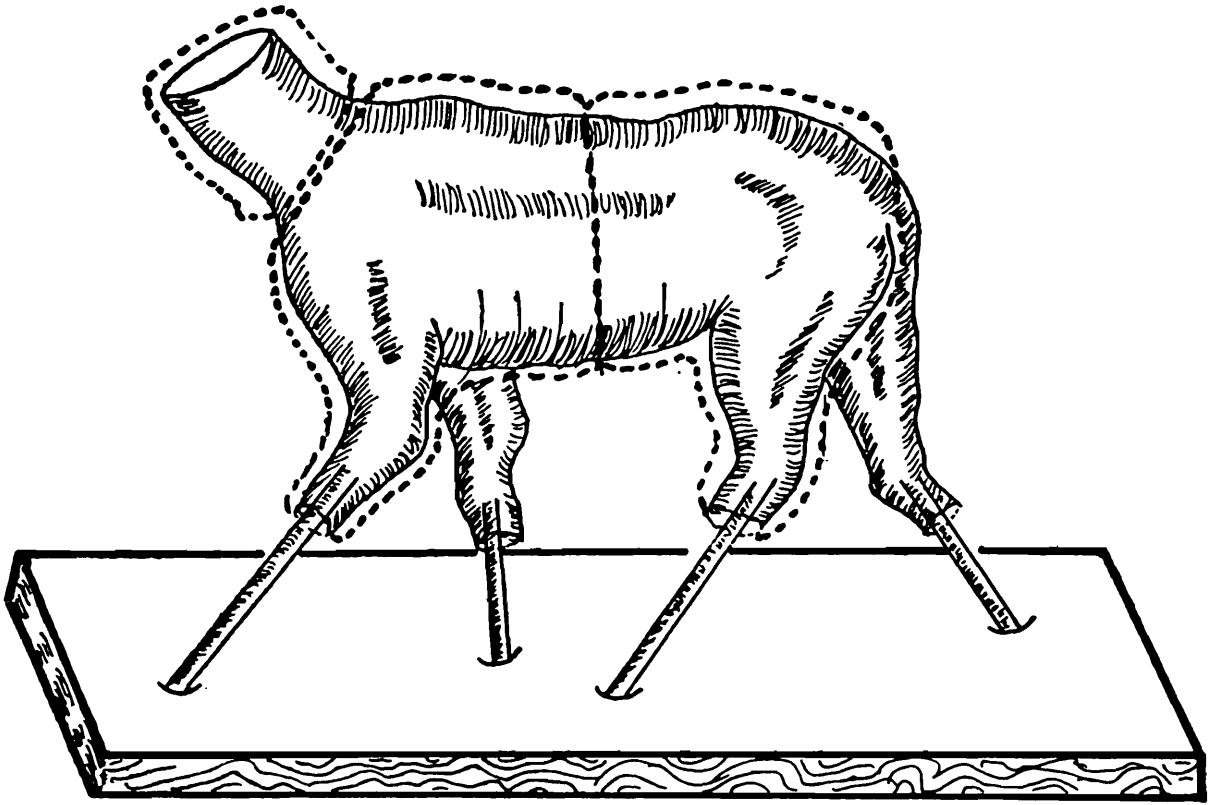


Fig. 5—Preparation of mould from the clay model of a Chital, *Axis axis*.

cast as well as to absorb moisture. It was allowed to dry in a shed rather than in sun to avoid crumpling of the edges of the cast. During the process of drying the sand was changed thrice at an interval of three, seven, and fifteen days. In summer, the casts were separated from the moulds after six weeks. In the anterior and posterior pairs of body-casts, respective limb-rods along with the wooden strips were screwed correspondingly on the inner surface of the casts. Both these anterior and posterior pairs of upper body-casts were again erected and fixed on the mounting board in a similar manner as described earlier. The two pieces of belly-casts were also fixed accordingly. In one piece of the neck-cast, a round wooden peg was screwed to hold the skull, and this pair was also joined and fixed to the body-cast. Thus the entire eight pieces of casts were assembled to give the shape of the original clay model. In this hollow papier-mache mannikin the skull was fixed by inserting the wooden peg in the foramen magnum. All the spaces between the walls of the casts as well as the marks of stitches on the mannikin were patched with the papier-mache compound and allowed to dry for about a week. After complete drying, the entire surface was retouched to bring up even the minor details of contour and depression of muscles as well as the prominence of veins with the help of modelling material. Finally, the roughness of the mannikin-surface was filed down and sandpapered to make it smooth as far as practicable. Subsequently the mannikin was given a coat of 'black Japan' as water-proofing. The treated skin, duly soaked in alum solution was placed over the mannikin and stitched. In case of the stag, the detached antlers were screwed over the pedicel. The eyes were fixed and waxed



Fig. 6—A habitat case of Chital, *Axis axis*.

as well as all the soft parts were retouched. Finally a coat of 0.05 percent mercuric chloride solution, prepared in 90 percent ethyl alcohol, was given as a dressing to avoid any possible fungal infection. Before displaying, it was fumigated (Appendix II).

### *Display*

The Indian Museum originated in 1814 with the collection of the Asiatic Society. In 1865 the museum collection was shifted to the present building and the Zoological Galleries were established during 1878. The display of the exhibits are of the old concept in fixed running showcases of different sizes along the walls. Now to make any radical change in the display is difficult as well as costly. However, under the existing circumstances, a habitat case of Chital (Fig. 6) from the sal (*Shorea robusta*) forest of Madhya Pradesh was introduced in the mammal gallery. The dimension of the case (length approx. 4 m., width 3.75 m. and height 3 m.) was dependent on the availability of space. The vegetation of the habitat case, ranging from grass to trees were manipulated artificially. The difficulty of merging the foreground with the background was overcome by relief-painting.

## SUMMARY

Animals procured for taxidermy purpose should be dealt with before the decomposition starts. Necessary measurements, namely the total length from occipital region to the tip of the tail, from the apex of the throat to the insertion of the tail, greatest width in the centre of the body, girth of neck, the distance between the inner borders of the fore and hind limbs, height at shoulder, etc., should be recorded preferably over a sketch of the animal concerned. Mounting of small mammals like shrew, rat, hare, squirrel, etc., are normally done by the round-type of skin along with skull and complete bones of the limbs. During skinning, the body is extracted out carefully from the round-type of skin through the belly incision by disarticulating the hip joints and the leg muscles from the pelvis, and the fore limbs at the shoulder joints, besides severing the ears, eye-lids, lips, and nose close to the skull. Mounting of large mammals is done with either flat skins or skins removed by means of the full-length dorsal incision. For the flat-type, slit the skin underneath, in a straight line through the under lip to the tip of the tail, then make four cross cuts from the median line along the inside of limbs down to the toes and skin out the body stripping cautiously around the head region, namely ears, eyes and nostrils. This method is in practice in our museum for the animals like cat, deer, yak, elephant, etc. Skins removed by means of the full-length dorsal incision are suitable particularly for primates. Borax treatment is preferred for round-type of skins, but at times arsenical soap may also be used for preservation of skins. Such prepared skins are mounted over a body made of tow with the help of five galvanised wires of suitable gauge and length, and limb bones and a little bit of modelling with appropriate material. The flat skins should be salted, boraxed and scraped for about a week or more depending on the condition of skin. Subsequently salted skin should be washed thoroughly before giving the alum-bath for over two weeks. When the skin is ready, it may be mounted over any of the mannikins, made of jute, clay, plaster of Paris, framework of wood and wire-mesh or even on hollow cast of papier-mache obtained through the model. After the drying of the exhibits under shade, a dressing of the coat with dichloride of mercury in 90% alcohol is required particularly in humid region.

Display of exhibits varies according to needs and expertise. It may be exhibited in an artificial replica of natural surrounding. Such display is commonly called habitat case or diorama. Size of such cases are directly proportional to the availability of space and fund and the habit and size of the animal concerned.

The mounting and display will need a combined effort of carpenter, modeller, artist, taxidermist and scientist. Efforts and efficiency of individual will lead to perfection.

## ACKNOWLEDGEMENT

The author is thankful to the Director, Zoological Survey of India, for the facilities. Further, he is indebted to the organisers of the workshop for extending the invitation to present my paper, last but not the least to Dr. K. C. Jayaram, Dr. O. B. Chhotani, Dr. V. C. Agrawal, and all the staff of the Museum & Taxidermy section and to Shri S. K. Talukder, of the Zoological Survey of India for their assistance during the preparation of this paper.

## APPENDIX-I

1. *Alum—borax paste*

Alum	...	4 parts
Borax	...	1 part
Water	...	according to requirement, to make it a paste.

2. *Arsenical paste*

Arsenic oxide	}	...	1 part
or			
Arsenious trioxide			
Soft soap (having less caustic)	...	3 parts	
Zinc oxide	...	3 parts	
Camphor	...	$\frac{1}{4}$ part	
Water	...	according to requirement, to make it a paste.	

3. *Dressing mixture*

Common salt	...	4 parts
Borax	...	1 part
Carbolic acid	...	very little. (For a Chital skin about 100 cc was used.)
Water (warm)	...	according to requirement.

4. *Alum bath*

Alum	...	5 parts
Potassium nitrate	...	1 part
Potassium dichromate	...	small quantity (about 300 g were used for each skin of chital).
Water	...	according to requirement.

## APPENDIX-II

1. *Papier-mache compound*

- |                         |     |   |  |
|-------------------------|-----|---|--|
| 1. Paper pulp           | ... | 4 parts.                                  | Cardboard well soaked in water with a little amount of KOH for about a week, squeezing the solution, beaten to fine particles. |
| 2. White powder (Chalk) | ... | 1.5 parts                                 |  |
| 3. Linseed oil          | ... | 3 parts (preferably burnt)                |  |
| 4. Glue                 | ... | 1.5 parts (molten over water bath)        |  |
| 5. Arsenic oxide        | ... | 100 g for an animal of the size of Chital |  |
| 6. Water                | ... | according to requirement.                 |  |

The beaten fine cardboard particles were mixed with the other ingredients and beaten to make the compound as modelling clay.

2. *Chemicals used for fumigation*

- |                        |     |          |
|------------------------|-----|----------|
| 1. Ethylene dichloride | ... | 1 part   |
| 2. Carbon disulphide   | ... | 0.5 part |
| 3. Benzene             | ... | 1 part   |

The exhibit was exposed to the mixture of the above chemicals in an airtight chamber for two weeks.

## DISCUSSION

- Q. Can you tell something about softening process for an old hardened mammal skin.
- A. Old preserved skins can be softened by the alum bath.

## **BIODETERIORATION OF MAMMAL COLLECTIONS IN MUSEUMS**

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### **INTRODUCTION**

Mammal collections in the form of study skins or mounted specimens are susceptible to a wide range of insect attack. The presence of protein as keratin and collagen in them attract several insects which feed on such material. Dermestid Beetles and Clothes Moths account for the heaviest amount of damage that is caused to mammalogical collections in museums in tropical countries like India. This paper presents some of the observations on the biodeterioration of mammal collections and discusses methods for prevention and control of the problem.

Of all the insects known to cause damage to museum collections, the Dermestid Beetles are most conspicuous in India. About 52 species of Dermestidae are reported as pests of stored products throughout the world (Patel, 1958). The name *dermestidae* has originated from the Greek word meaning "to devour a skin". These beetles are known to feed on skins, hides, leather, taxidermy specimens of birds and mammals, hair, fur, feather, woollen carpets, fabrics, dried entomological specimens, etc. It is believed that originally the dermestid larvae fed on skins, hooves, horns, feathers, etc., of cadavers found lying on the ground in the open. Artificial conditions created by man in households, stores, museums, libraries, etc., have proved so ideal that many have been drawn from their natural habitats, adopting a new mode of life. The adults of these species still live outdoors frequenting flowers and feeding on pollen (Hinton, 1945). Today Dermestid Beetles are distributed throughout the world inhabiting a wide range of ecological niches and feeding on a variety of materials.

The dermestids, in general, possess certain remarkable adaptations enabling them to live under varied nutritional and environmental conditions. They can thrive on a variety of organic materials without imbibing water, withstand fairly wide variations of temperature and humidity and survive long periods of starvation when food supply fails. The egg

production is autogenous, the majority of eggs being laid without feeding, which again is a definite advantage for the survival of the species.

A large number of dermestid beetles, belonging to the genera *Anthrenus*, *Attagenus*, *Dermestes*, and *Trogoderma* are recorded as pests in museums. According to Patel (1958), the genus *Anthrenus* alone accounts for 8 different major pest species. These are *Anthrenus flavipes* Le Conte (Furniture-Carpet Beetle), *Anthrenus scrophulariae* (Linnaeus) (Common Carpet Beetle), *Anthrenus verbasci* (Linnaeus) (Varied Carpet Beetle), *Anthrenus museorum* (Linnaeus) (Museum Beetle), *Anthrenus pimpinellae* Fabricius, *Anthrenus coloratus* Reit, *Anthrenus fuscus* Oliver and *Anthrenus caucasicus* Reitter.

The common museum pests of the genus *Attagenus* are *Attagenus gloriosae*, *Attagenus pellio* and *Attagenus elongatus* all known as Carpet Beetles, *Attagenus megatoma* (Black Carpet Beetle) and *Attagenus fasciatus* (Wardrobe Beetle).

The genus *Dermestes* contains pest species such as *Dermestes vulpinus* Fabricius (also named as *Dermestes maculatus* De Geer) commonly known as the Hide Beetle or Leather Beetle, *Dermestes frischi* Kug also known as Hide Beetle, *Dermestes lardarius* Linnaeus (Larder Beetle) and *Dermestes ater* De Geer (Black Larder Beetle).

The genus *Trogoderma* consists of *Trogoderma granarium* Everts (Khapra Beetle), *Trogoderma ornatum* (Say) (Cabinet Beetle), *Trogoderma variabile* Ballion (Warehouse Beetle) and *Trogoderma inclusum* Le Conte also known as Cabinet Beetle.

### **The Furniture Carpet Beetle**

The Furniture Carpet Beetle, *Anthrenus flavipes* Le Conte (Fig. 1) is the most widely distributed and most harmful of the several species of dermestid beetles found in tropical countries. In India *Anthrenus flavipes* was first recorded from Madras in 1883 by Waterhouse and later by Cotes (1890) who found it on dried mammalian skins in the Indian Museum, Calcutta. The larva of this beetle is particularly adapted for feeding on keratinous materials. Considerable damage is caused to hair and fur of mammal specimens, horn and antler. Temperatures ranging from 30 to 32°C are most ideally suited for the development of the eggs of *Anthrenus flavipes*, requiring only 6 to 10 days for incubation. At lower temperatures the incubation period increases, for example, at 20°C the period required for hatching may be about a month.

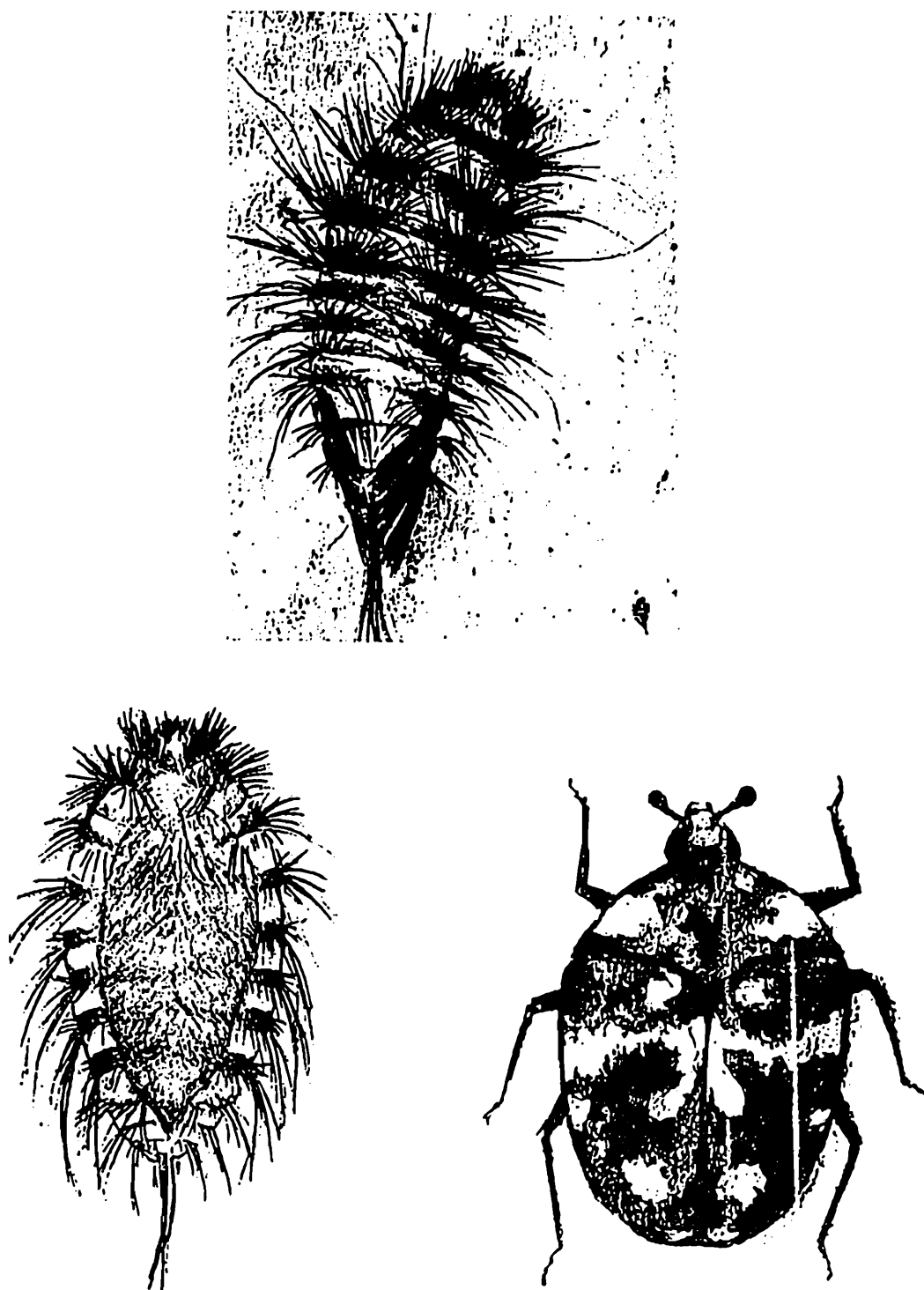


Fig. 1.—Life cycle stages of the Furniture Carpet Beetle, *Anthrenus flavipes*—larva, pupa and adult.

Humidity does not produce any appreciable variation on the incubation period. 30 to 32°C is also found to be ideal for the larval development and feeding activity. Variation in temperature upto 40°C does not affect the larvae in their normal feeding behaviour. It was also observed that temperature between 30 and 35°C is favourable for metamorphosis of the insect from pupal stage to the adult. These factors account for the wide spread distribution of *Anthrenus flavipes* in tropical countries.



Observations made on the feeding response of the larvae introduced on different kinds of food material showed that wool, horn, feather, dried insects, hair and fur form their most preferred diet. On mammal collections infestation by *Anthrenus flavipes* larvae are seen mostly on hair/fur and horns and hooves which are rich in keratin.

### The Hide Beetle

The Hide Beetle or Leather Beetle, *Dermestes vulpinus* Fabricius (*maculatus* De Geer) is also a serious pest of mammalogical collections (Fig. 2). In India, though they have been found feeding upon museum specimens of birds, mammals, hair, feather, fur, dried entomological collections, wool, bristles of brushes, horn, antler, etc., it was noticed that their strong preference is raw hides and skins, vegetable tanned leather, and dried fish.

Temperature ranging between 25 and 30°C and relative humidity above 70% are ideal for the growth of the larvae of *Dermestes vulpinus*. They cannot tolerate the extreme hot summer weather, which accounts for the fact that they are not as common in museums in India as are *Anthrenus flavipes*. They are often found in large numbers in dried-fish markets and tanneries where raw skins and hides are stored. While infesting mammalogical collections they usually feed on the skin portion of specimens, especially in cases where the preservatory treatments have been inadequate.

The larvae of *Dermestes vulpinus* are used successfully by several natural history museums for making osteological preparations. They do an excellent job of cleaning the skeletons by feeding upon the dried and semi-dried fleshy matter leaving the bones and cartilages intact. They would feed upon the flesh even of specimens that were previously preserved in alcohol.

### The Carpet Beetle

Several species of the genus *Attagenus* are described as Carpet Beetles. According to Kingsolver (1981) Carpet Beetles found in U.S.A. are the Varied Carpet Beetle *Anthrenus verbasci*, the Black Carpet Beetle *Attagenus megatoma*, and the Carpet Beetle *Reesa vespula*. *Attagenus gloriosae* (Fig. 3) is the most common Carpet Beetle found in India harmful to museum collections. These are known to be confined mostly to the tropical humid regions of the world. *A. gloriosae* was first recorded in houses in Hawaii in 1955. According to Willcocks (1922) it is a common household pest in Egypt where the larvae feed on skins,

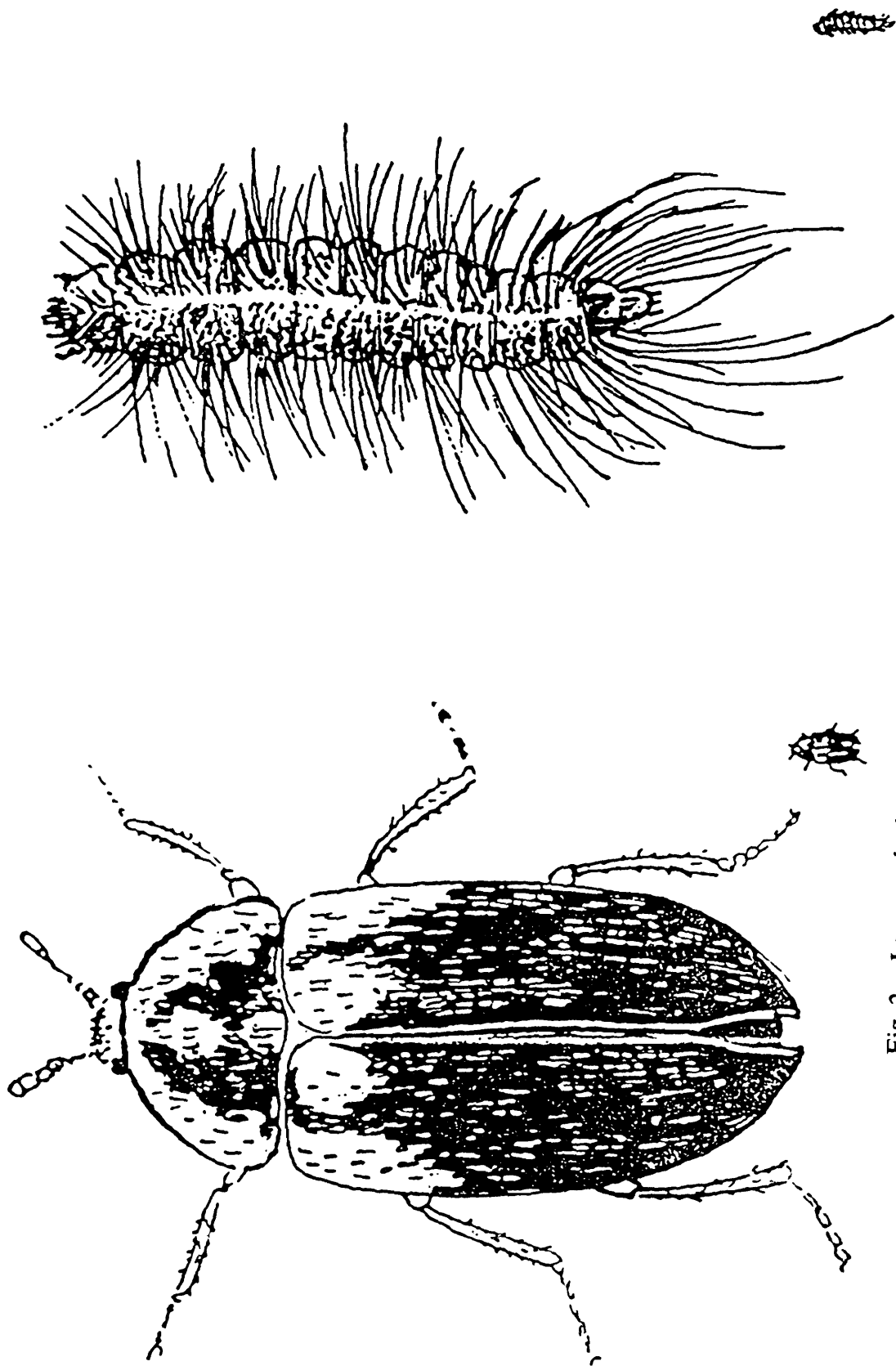


Fig. 2.—Larva and adult of the Leather Beetle, *Dermestes vulpinus*.

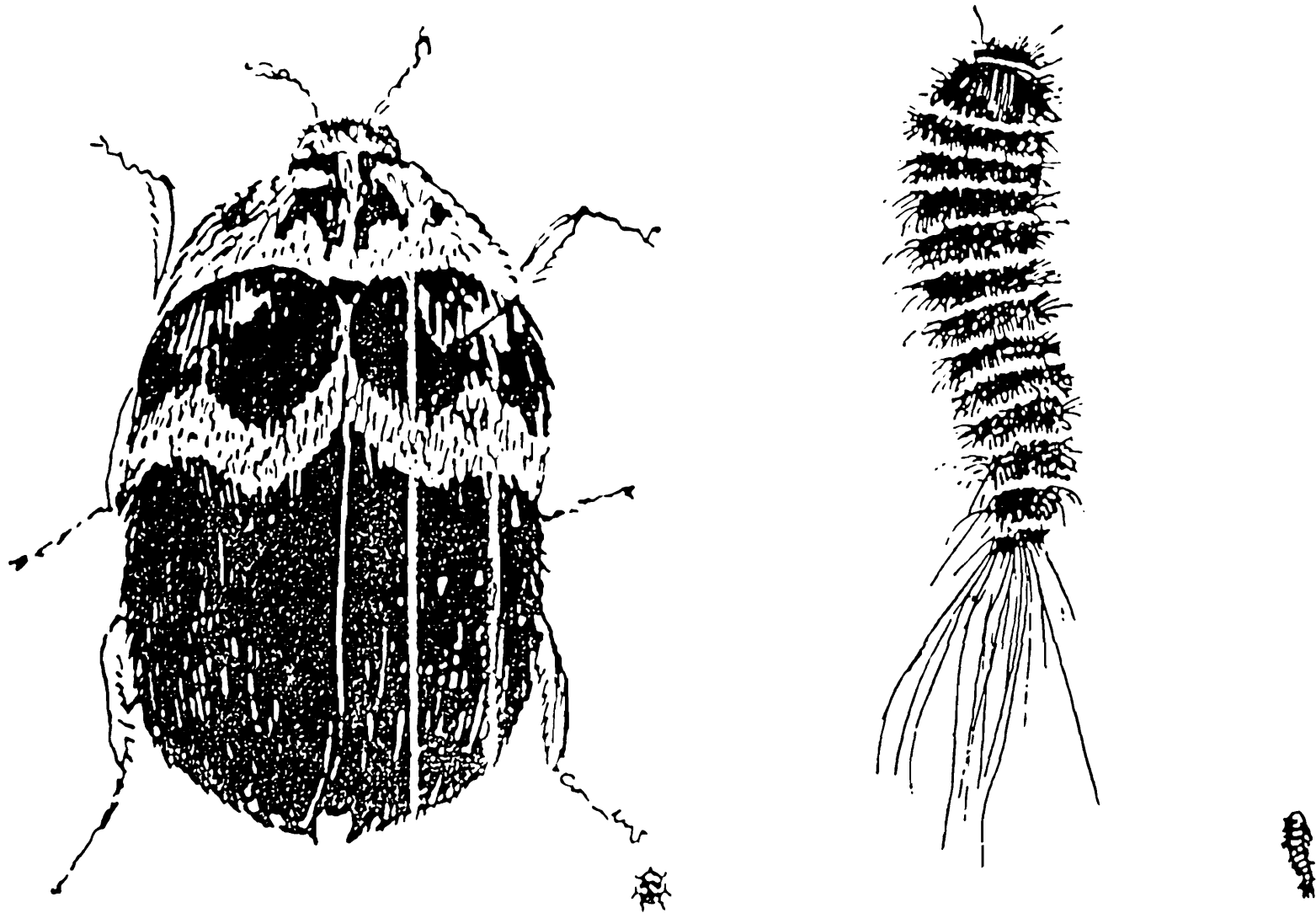


Fig. 3.—Larva and adult of the Carpet Beetle, *Attagenus gloriosae*.

fur, feathers, woollen garments, and carpets. Kalshoven (1935) recorded it from Java in horse hair in store houses. Szent Ivany (1968) mentions that the larvae of this insect have been found damaging specimens of insects in New Guinea. The insect was introduced in England, according to Hinton (1945) during 1934 through cargoes coming from India.

In India it is mostly found as a household pest of woollen fabrics and among collections of woollen textiles and carpets in museums. They have been found occasionally infesting hair and fur in mammal collections in museums. Keratin, particularly of hair, is the diet most preferred by the larvae of *A. gloriosae*. Temperature ranging from 30 to 32°C are ideal for its growth ; humidity is not having any appreciable effect on their feeding activity.

Among the three dermestid beetles mentioned above, *Anthrenus flavipes* and *Attagenus gloriosae* cause damage to hair and fur, the former feeding also on horn, antler and hoof (also keratinous in nature). *Dermestes vulpinus*, on the contrary, prefer collagenous protein and therefore cause damage to the skin portion of mammal specimens.

Other dermestid beetles recorded as museum pests in different parts of the world include the Museum Beetle, *Anthrenus museorum*, Larder Beetle, *Dermestes lardarius* (Wagstaffe and Fidler, 1968), Varied Carpet Beetle, *Anthrenus verbasci*, Black Carpet Beetle, *Anthrenus megatoma*, Carpet Beetle, *Reesa vespula*, Cabinet Beetle, *Trogoderma inclusum*, and the Khapra Beetle, *Trogoderma granarium* (Kingsolver, 1981).

### **The Case-bearing Clothes Moth**

The Case-bearing Clothes Moth, *Tinea pellionella* Linnaeus (Fig. 4) is a common pest of woollen fabrics in India. Laboratory studies on the feeding habits of the larvae of this insect showed that they can thrive on several kinds of protein substances, particularly where keratin is abundantly present. They have been found infesting on hair and fur in mammal collections in India, though not as frequently as the larvae of the Furniture Carpet Beetle.

The larva of *T. pellionella* constructs a cigar shaped case around its body with which it moves about (hence the name Case-bearing Clothes Moth). The presence of the larva is not easily seen because the outer surface of the case is covered with small pieces of the hair/fibre cut and pasted on to it. As a pest this insect is more of a problem to woollen fabrics, and infestation on mammalian hair in museum collections are of comparatively lesser significance.

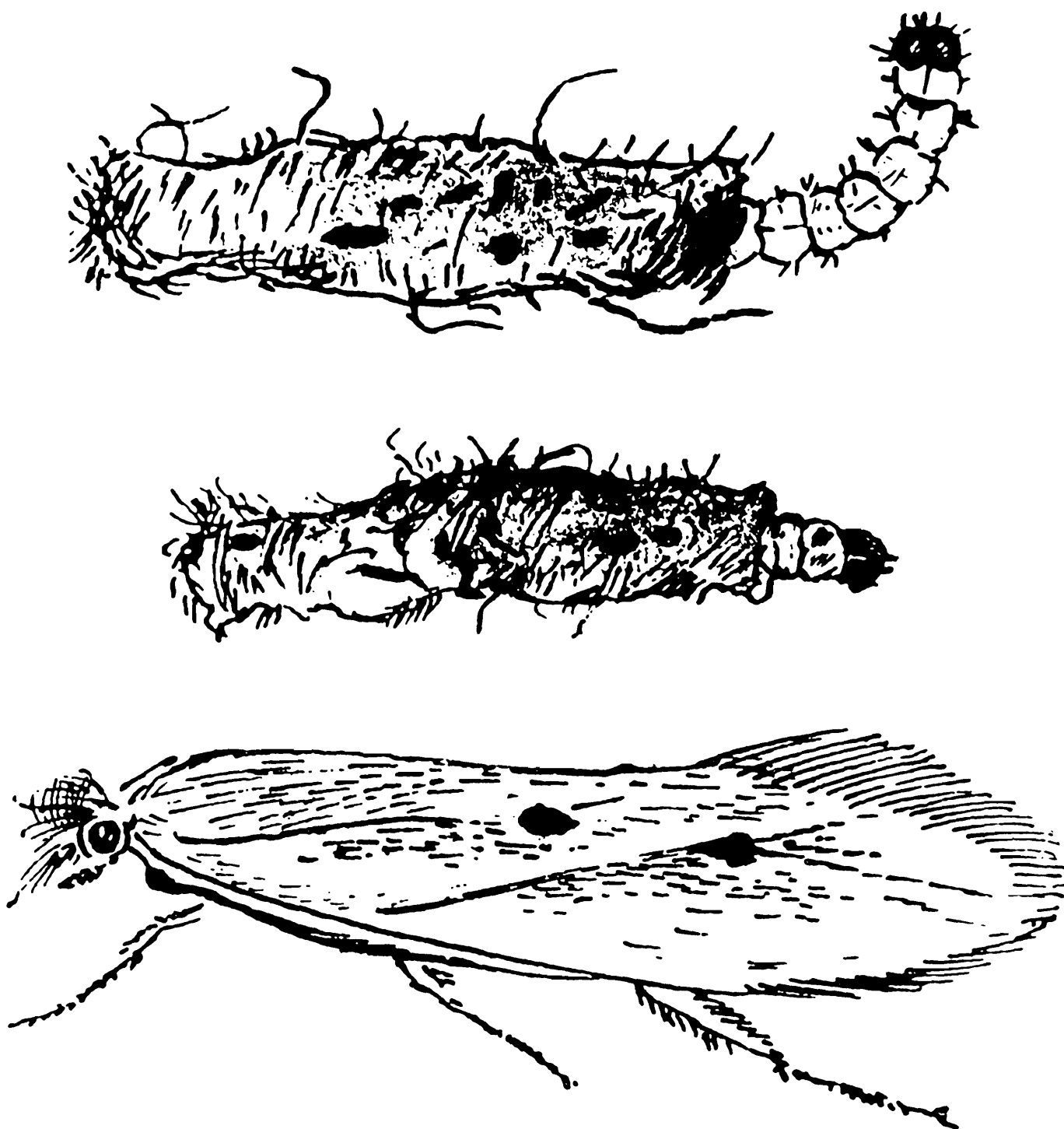


Fig. 4.—Larva and adult of Case-bearing Clothes Moth, *Tinea pellionella*.

#### Other minor pests

Other minor pests of mammalian collections in museums include the Spider Beetle, *Gibbium psylloides* (Czemp) capable of feeding on animal skins the Redlegged Ham Beetle, *Necobia rufipes* De Geer, reported from Freeze-Dry Laboratories in U.S.A. (Edwards and Bell, 1981), feeding on dried animal flesh as found in animals preserved by the technique of freeze drying the Drug Store Beetle, *Stegobium paniceum* (Linnaeus) reported to feed on leather (Kingsolver, 1981) the Tapestry Moth, *Trichophaga tapetzella* (L) and the Common Clothes

Moth or the Webbing Clothes Moth, *Tineola bisselliella* (Hum) that could feed on hair and fur (Wagstaffe and Fidler, 1968), etc.

### PREVENTION AND CONTROL

The treatment of museum objects against biodeterioration caused by insect pests should include preventive measures aimed at forestalling the possibilities of infestation and control measures required to be undertaken once the infestation has already taken place.

Preventive measures should primarily consist of “good house-keeping practices” that prevent opportunities for insects to survive inside the museum premises. Proper storage conditions, regulation of temperature, humidity and ventilation and periodical inspection of collections are essential factors to be attended to at all times.

Preventive treatments required can be grouped conveniently into two categories :

- (i) Chemical treatments given to the skins during preparation and
- (ii) the use of chemical repellants within storage and display cabinets.

The first category consists of chemical treatments given by taxidermists in the preparation process of study skins and mounted specimens. They vary from dusting the inner side of the skin with arsenic oxide or a mixture of arsenic and borax to elaborate tanning processes. A large number of chemicals and chemical formulations are used by taxidermists to prevent insect attack on mammal specimens. Some of them are mentioned below :

#### *Arsenic-borax powder*

A mixture of equal portions by volume of dry white arsenic and powdered borax (Sodium tetraborate) is applied on the inner side of skins, mostly in bird specimens during the process of taxidermy. It keeps the skin supple and prevents insect attack.

#### *Arsenic-Alum powder*

A mixture of equal portions by volume of white arsenic and powdered alum (potassium aluminium sulphate) is used for the same purpose as the above mixture.

*Wagstaffe-Barrow Mixture*

A mixture for dry application to bird and mammal skins from the inside is made in the following proportion (Wagstaffe and Fidler, 1968).

Borax powder	—	500 g
Tannic Acid	—	30 g
Camphor	—	16 g
DDT	—	3.5 g
Beechwood Creosote	—	9 drops

*Hornaday's Arsenical Soap*

A formulation, recommended as the finest mixture for treatment of bird and mammal skins (Wagstaffe and Fidler, 1968) is made with the following ingredients :

White bar soap (soft variety)	—	1 kg.
Powdered white arsenic	—	1 kg.
Subcarbonate of potash	—	190 g
Camphor	—	150 g
Alcohol	—	250 cc

*Salt-acid Tan Solution*

Common salt	—	250 g
Sulphuric acid	—	30 cc
Water	—	5 litres

(The salt and water to be mixed first and sulphuric acid added to it).

*Sulphonated Neat's foot oil* (Moyer, 1953)

Sulphonated Neat's foot oil	—	1 part
Water	—	1 part

(Water to be warmed a little and mixed with the sulphonated oil).

*Alum solution* (Moyer, 1953)

Water	—	1 gallon
Salt	—	1/2 lb
Alum	—	1/4 lb
Carbolic Acid	—	1/2 ounce

*Rowley's Mixture*

(for preservation of Antlers in "velvet", Wagstaffe and Fidler, 1968)

Water	—	1 litre
Glycerin	—	2 litres
Salt	—	400 g
Alum	—	400 g
White Arsenic	—	400 g
Formalin	—	500 ml

*Arsenical paste*

White Arsenic	}	equal quantity
Zinc oxide		
Soft soap		

(Boiled together in water to form a paste. A few crystals of camphor to be mixed when cool.)

The insecticidal chemicals or chemical formulations mentioned above are used for application on the flesh side of the skin in birds and small mammals during the process of taxidermy. In the case of larger animals, however, the skin is tanned to strengthen it as well as to prevent biological deterioration.

Animal specimens preserved by the process of freeze drying are also prone to insect attack. Susceptibility to biodeterioration is more acute in such specimens because no chemical treatments are given to the skin as in the case of taxidermy. Furthermore, the body tissues including fats are dried *in situ* and therefore a larger amount of nutritional matter is available for insects to thrive upon. Adequate precautionary measures to prevent insect attack are very essential for freeze-dried zoological specimens.

The second category of preventive measures consist of the use of repellents. Paradichlorobenzene and Napthalene are the two most commonly used repellent chemicals in zoological collections. The latter is less effective compared to the former.

Wagstaffe and Fidler (1968) are of the opinion that Paradichlorobenzene has some deleterious effect on certain colours of bird and mammal skins, although there is no conclusive evidence in this respect. Most museums use this chemical in storage boxes and display cases containing dried animal specimens with success.

The British Museum (Natural History), London recommends the use of a mixture of Chloroform, Creosote and Napthalene (C.C.N.)



named as British Museum Mixture as a suitable insect repellent. Observations made in India show that a mixture of Paradichlorobenzene, Benzene and Creosote (P.B.C.) is a highly effective repellent. Edolan U is another mothproofing agent recommended for application on specimens for repellent action.

Fumigation with suitable chemicals is the best method for eliminating insect pests from affected specimens. A large number of fumigants are available today. Wagstaffe and Fidler (1968) recommend liquid fumigants such as Ethylene dichloride, Methyl formate or Carbon disulphide. All of them are highly inflammable. A mixture of Ethylene dichloride and carbon tetrachloride (3:1 by volume) is a satisfactory non inflammable mixture. Methyl Bromide is also a very useful fumigant. Periodic inspection of specimens for possible biodeterioration and immediate isolation and treatment of affected materials are necessary to ensure proper preservation of mammalogical collections in museums.

#### SUMMARY

Mammal collections in museums and related institutions in the form of study-skins or mounted specimens are susceptible to various kinds of deterioration. In tropical countries the destruction brought about by biological agencies such as fungi and insects is a major problem in the storage and display of such materials. Because of the protein contents of the skin and hair in the form of collagen and keratin respectively, certain insects especially adapted to feed on them cause severe damage to mammal specimens.

The most common insect pests of mammal collections in India are dermestid beetles and clothes moths. The species attacking museum collections, their characteristics, feeding habits and control measures are discussed in this paper. Also, pests of mammal collections reported from other countries, are discussed.

The prevention and control of biodeterioration of mammal collections through chemical treatments given during preparation of the specimen, use of repellants, insecticides and various processes involved in applying these control measures including fumigation are discussed.

#### REFERENCES

- COTES, E. C 1890. Miscellaneous notes. *Indian Mus. notes*, i, pp. 195-213.
- EDWARDS, R. S., Bell, M. B. and King, E. M. 1981. Pest control in Museums. The Association of Systematic Collections, U.S.A.

- HINTON, H E. 1945. A monograph of the beetles associated with stored products. I, British Museum Natural History.
- KALSHOVEN, L. G. E. 1935. Dermestiden in Nederlandsch. *Indian Ent. Med. Ned. Ind.*, 1 : 4.
- KINGSOLVER, J. 1981. 'Illustrated Guide to common insect pests in Museums.' Appendix 'B' of pest control in Museums, Edwards R. Stephen *et al.* Association of Systematic collections, U.S.A.
- MOYER, W J. 1953. Practical Taxidermy. Ronald Press Co., New York.
- NAIR, S. M. 1971. 'Certain observations on the biodeterioration of Museum Materials in India' Biodeterioration of Materials, Vol. II. Applied Science Publ., London.
- PATEL, H. K. 1958. The Furniture Carpet Beetle (*Anthrenus vorax* Waterhouse). *Mem. ent. Soc. India*, No. 6, 47 pp.
- SZENT-IVANY 1968. Identification and control of insect pests. The Conservation of Cultural Property. Museums and Monuments series, Unesco.
- WAGSTAFFE, R. and FIDLER, J. H. 1968. The Preservation of Natural History specimens. Vol. II. H. F. & G. Witherby Ltd., London.
- WATERHOUSE, D. F. 1958. Wool digestion and mothproofing. Advances in Pest Control Research. Interscience Publishers, New York.
- WILLCOCKS, F. C. 1922. A survey of the more important economic insects and mites of Egypt with notes on life-history, habits, natural enemies, and suggestions for control. *Bull. agric. Soc., Cairo*, 1 : 8 : 483.

#### DISCUSSION

- Q. Clothes moths are generally considered to be greater pests to Museum-specimens than dermestid beetles in tropical countries. Is this true for Museum-collections in India ?
- A. Dermestid beetles, namely *Anthrenus flavipes* is the most predominant insect pest of Natural History Collections in India. Clothes-moth damage is less frequent.
- Q. What is the effect of chemical degradation (formalin) and other insecticides on the specimens ?

- A. This is a very important aspect of pest control operation. It is important to select a chemical that is not harmful to the object, least toxic to man and most effective to pest in question.
- Q. Would you please describe the proportion of materials used for the repellent mixture CCN and PBC ?
- A. For CCN, add naphthalene to a quantity of chloroform to make a saturated solution. Decant and add an equal quantity of creosote. For PBC a mixture of Paradichlorobenzene 50 gm, Benzene 50 cc and Creosote 50 cc are required.
- Q. Could you tell the problems caused by fungi or mildew ?
- A. Already discussed in the paper.
- Q. Do PBC or the British Museum Mixture have any effect on the colour of mammal pelage? Also do these substances etch plastic or corrode exposed metal ?
- A. There is no conclusive evidence on PBC or British Museum Mixture affecting the colour of specimens. These are not applied to specimens but kept in storage vaults to have the repellent fume within. British Museum Mixture and CCN could etch plastic in direct contact because of the presence of chloroform and benzene.
- Q. Do you think, the technique of freeze-drying will ever become feasible a cost effective method of preparing research specimens?
- A. This technique cannot replace taxidermy. It is useful only for small and medium-sized specimens, for use as display items.
- Q. How often a displayed material needs to be fumigated ?
- A. Displayed material need be fumigated only if it shows signs of insect attack. Repeat once or twice.
- Q. Do you use regular checking and cleaning of specimens ?
- A. This is a very important aspect of maintenance.

## **IMPORTANCE OF PROPER LABELLING OF MAMMALIAN SPECIMENS**

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### **INTRODUCTION**

A mammalian taxonomist today is not satisfied with merely establishing the taxonomic identity of the specimens before him, but is also eager to study variations, geographic or otherwise, which exist among them. For such studies the specimens should have labels accurately depicting adequate data regarding the locality, date of collection, sex, various measurements, and a host of other essential information. Specimens without such informative labels are liable to prove useless for the study of variation. Most unfortunately, a very large number of mammalian specimens housed in various institutions of the world, including the Zoological Survey of India, suffer from such inadequacy of data of the labels, and are, therefore, not very useful for modern taxonomic research.

Much attention is paid towards the routine care of specimens by institutions engaged in the maintenance of mammalian collections. Huge sums of money are also spent to augment such collections. But the attention paid towards proper labelling of the specimen by many of these institutions can perhaps be rated as inadequate while a serious thought on the quality of the material for the label is almost non-existent in them. The details of the information to be entered on the label, the quality of paper, ink and string to be used in proper labelling of mammalian specimens, and necessary precautions in connection with them are, therefore, discussed in this paper.

In most of the institutions of the world, including the Zoological Survey of India, mammalian specimens have two categories of labels, viz., the field label and the institutional label.

### **FIELD LABEL**

The field label is written in the field itself. This label being the first label to be tied to a specimen, is also known as the 'original label'. The field label is written by the collector of the specimen. It is, therefore, otherwise called the 'collector's label'. This label is further designated as the 'permanent label' because it is never replaced and is maintained as long as the specimen remains.

*Minimum data required on the field label*

In order that the specimen becomes worthy of use in connection with modern taxonomic research, its field label should have some minimum data entered on it (Fig. 1). They are :—

*Locality*

This is the most important single piece of information required on a field label. A specimen can be utilised in a study of geographical variation only if its label precisely bears the locality from where it was collected. It is desirable to use the current name of the locality and to follow only the standard spelling. To avoid confusion regarding a recent change in the name of a place and its spelling, it may sometimes be necessary to give the older name and spelling in parenthesis, *e.g.*,

Sumatera (=Sumatra), Bardhaman (=Burdwan), Beijing(=Peking), Boudkhandmals (=Phulbani), Chandrapura (=Chanda), Hugly (=Hooghly), Pune (=Poona), Saptagram (=Adisaptagram), Thane (=Thana), Xizang (=Tibet), etc.

Again, mentioning only the name of the place from where the specimen was collected, is, in most cases, not enough. If a specimen obtained from India has entries like Ramgaon, Ramgarh, or Rampur on the label as its locality, it practically conveys no idea as to the exact locality from where the specimen was collected for there are 14 different Ramgaons, 92 Ramgarhs, and as many as 319 Rampurs in India. Even Rampur, Uttar Pradesh, India, is not of much help. Because there are 284 Rampurs in Uttar Pradesh itself. Mentioning of the name of the district after the name of the place is sufficient in most cases. But even this fails when there are more than one locality having the same name in the same district. Thus, Rampur, Faizabad district, Uttar Pradesh,

◦	Siron (Gir Forest), c 18km SE of Sason, Junagadh Dist., Gujarat [c 21°6'E, 70°41'N].	GFM33
◦	B. Biswas      1 Dec 1962	♀

H&B	154	Common in cultivated fields of	◦
Tl	174	wheat & millet.	
Hf	35	Nocturnal.	
E	21	Mammæ: 1+2 = 3 pairs	
Wt	170 gm	Grauid : 2 foetuses in right horn & 4 in left.	◦

Fig. 1. A field label for a mammal specimen

India, is not quite indicative, for there are 52 Rampurs in Faizabad district alone. In situations like this and when the name of the locality is not to be found in commonly available maps, the approximate distance and direction of the locality from a well-known place (and indicated in such maps) are to be added after the name of the place. This will unmistakably pinpoint the locality in question. The distances is to be calculated in a straight line (as the crow flies) and expressed in kilometres. The following abbreviations may be used in this connection :

c=approximately, km=kilometre, N=north, SE=southeast, NNW=north-northwest, and so on.

Incidentally, Williams *et al.* (1977) suggest that to avoid difficulties in pinpointing a locality, it should be shown with reference to the major compass points only, *i.e.*, north, south, east and west, and not with reference to other compass point subdivisions such as northwest, southeast, east-northeast, south-southeast, etc. According to this method the distance of a locality from a specific reference point should be shown in the longitudinal direction (north or south), followed by the distance of the locality from the same reference point in the latitudinal direction (east or west). For example, Balivasa, a small village in Medinipur district of West Bengal, should be expressed as 'Balivasa, 10 km S, 15.5 km E of Jhargram, Medinipur district, West Bengal', rather than 'Balivasa, c 15 km SSE of Jhargram, Medinipur district, West Bengal'

Surely the method suggested above is a better one in pinpointing a locality. But most countries of the world including parts of the United States of America follow up to tertiary subdivisions of the primary compass points in expressing less known localities. The Zoological Survey of India still finds this method satisfactory.

It would, therefore, follow that statements like '7 km N of Forest Rest House' and 16 km from Berhampur, are practically of no help in determining the exact locality. Structures like the forest rest house, dak bungalow, irrigation bungalow, inspection bungalow, etc., are in no way permanent. As per demand of the situation, new rest houses and bungalows are constructed after several decades at locations situated at distances of several kilometres from the earlier ones and the older structures may even be demolished. In the second case, only the distance from a well-known place is given, but not the direction, and, therefore, is not helpful in finding out if the location is 16 km north, south, east or west of Berhamur.

Statements like 'Tirupati, Andhra Pradesh, South India,' 'Darjiling, North Bengal', 'East Africa', etc., are to be avoided. No part of India is officially designated as South India. If, however, the southern portion of India must be emphasised, southern India (meaning only

southern portion of India) may be added after Andhra Pradesh. Similarly, there being no area officially known as North Bengal, 'Darjiling, northern West Bengal' would be ideal if the northern part of the state of West Bengal is to be emphasised. East Africa as part of locality is to be avoided because at present there is no country known by that name, though several decades ago a portion of the eastern part of Africa used to be known as Portuguese East Africa. Here again, if the eastern part of Africa is to be emphasised, the entry 'eastern Africa' will be sufficient.

If a collection is made in hilly and montane areas, the altitude (in metres) of the place above the mean sea level (a.m.s.l. or m.s.l.) is to be given in parenthesis just after the name of the place. It is better to note the altitude of the actual location from where a specimen is collected, directly with the help of an altimeter. Different locations of the same locality may have appreciably different elevations. In such a case the actual elevation of the place of collection is to be entered after the name of the place, *e.g.*—

Bulfai (*c.* 2475 m), Manas Valley, Bhutan

Bulfai (*c.* 2621 m), Manas Valley, Bhutan

Bulfai (*c.* 2745 m), Manas Valley, Bhutan

As long as collecting is done in locations within a radius of five kilometres around a place, the name of that place can be entered as the locality. This procedure is based on the principle that mammalian populations generally do not vary significantly within such a small area.

For areas whose detailed maps are not yet available, mention of broad geographical features under the locality may help in indicating the place of collection. The detailed map of Bhutan has not yet been completed. Hence, instead of writing simply 'Bulfai (*c.* 2475 m), Bhutan' if the words 'Manas Valley' are added after Bulfai, it would be easier to locate the place.

One final word about making the entry regarding the locality on a label is that it is to be done in a manner which would pinpoint the place of collection of the specimen without any element of ambiguity, and only with this end in view any amount of deviation from the suggestions offered above is to be accepted without the slightest hesitation.

#### *Date of collection*

A specimen can be utilised in a study of seasonal variation (pelage condition, reproductive condition, etc.) only if its label mentions the date of its collection. Therefore, the date on which the specimen is collected is to be clearly entered on the label. Here again, it is to be done

in a manner so that there is not even the slightest doubt. An entry like 3-7-50 or 3-VII-50 is to be avoided for in many parts of the world it will mean the seventh day of the third month (March), while in other parts of the world, including India, it will mean the third day of the seventh month (July), and if both the label and the specimen are in depleted condition, it will be quite difficult to determine with certainty whether the specimen in question was collected in 1850 or in 1950. It is always safe to write the day of the month first followed by the first three letters of the month (not followed by a full stop) and the year in full. Thus, 3 Jul 1950 will always mean that the specimen was collected on the third day of the month of July in the year 1950, in every part of the world.

The date of collection means the date on which the specimen is actually killed for preservation. Normally the date of procurement and the date of preservation are the same. If, however, a living specimen is procured, kept alive for several days and is subsequently killed for preservation, both the date of procurement and that of killing are to be clearly stated.

#### *Name of collector*

The name of the collector of the specimen is to be clearly entered on the label. Usually prefixes like Mr., Dr., Fr., Br., Major, etc., need not be added to the name of the collector. But if there is any chance of confusion, such prefixes are to be added to make the situation clear. For example, at present, there are two A. K. Mandals at the Zoological Survey of India, and both collect mammals. One of them has a doctorate degree, the other does not have it. The first-named person can enter his name as Dr. A. K. Mandal against 'Collector,' while the other should write simply A. K. Mandal. This arrangement, however, will be valid till the second A. K. Mandal obtains his doctorate degree when perhaps the first person will have to write An. K. Mandal and the second Aj. K. Mandal, for their full names differ (Anil Krishna Mandal vs Ajay Kumar Mandal). Again, there are two persons in the Zoological Survey of India who both collect mammals and have exactly the same full name, viz., Ranjit Kumar Ghose. One of them is a mammalogist and is differentiated from the other in writing by adding 'I' in parenthesis after the name. The other person who is a helminthologist also collects mammals (as hosts of helminths). He is distinguished from the other person of the same name by putting 'II' in parenthesis after his name. These two collectors can utilise this system when entering their names as collectors.

The name of the collector on the label is desirable due not only to the fact that it indicates relative authenticity of the data on the label



but at times can also throw light on some other incomplete data supplied on the label. Surely the data on the label written by a trained mammalian taxonomist would be more authentic and informative than those of a layman collector.

Dobson (1876) lists three unsexed specimens of *Phyllorhina diadema* (Geoffroy) from Odeypore (=Udaipur) collected by V Ball. In the absence of any further information regarding the locality one is apt to take this locality as the well-known Udaipur of Rajasthan. This, of course, would be erroneous as V Ball collected in an area called Udaipur which is not in Rajasthan but in the present Raigarh district of Madhya Pradesh. Thus, so long as V Ball is the collector, the locality Udaipur is to be read as stated above. Sinha (1977) records *Megaderma spasma* (Linnaeus) from the Andaman Islands on the basis of a female specimen collected from Ross Island, and present in the National Zoological Collections of India housed in the Zoological Survey of India, Calcutta. There are at least two Ross Islands more familiar to workers on Indian mammals, one in the Andaman group of islands, and the other off the coast of Mergui Archipelago (Burma). The collector of Sinha's (*op. cit.*) specimen is C. Primrose who collected for the Mammal Survey of India, Burma and Ceylon organised by the Bombay Natural History Society during 1911-1930. The Mammal Survey never collected in the Andaman and Nicobar Islands, but did so in the Mergui Archipelago. The specimen in question was collected from Ross Island, Mergui Archipelago, and not from the one of the same name and included in the Andaman group of islands. This little bit of additional information about the collecting activities of the collector of his specimen would have been enough to enable the author to avert this erroneous conclusion.

### *Sex and age*

The sex of the specimen is to be written on the label by using standard notations, viz.,—♂ for the male and ♀ for the female. This piece of information is essential if the specimen is to be utilised in a study of variation due to sex. Most mammals pose no problem as regards their sexes. An examination of the external genitalia reveals the sex of the specimen in most cases. In many insectivores and juvenile rodents, however, sexing by this method may be difficult, if not impossible. Examination of gonads is the only method left in such cases. Females of megadermatids, rhinolophids and hipposiderids at times have each a pair of asymmetrical false inguinal teats. The penis in these groups of bats is quite slender. To make the situation worse, the longer of the false inguinal teats is often similar to the length of the penis. This appears to be the potential source of error in sexing (females labelled as males) of many specimens of hipposiderid and rhinolophid bats by Dobson

(1876). Hence, utmost care is to be taken in examining the external genitalia of these bats for sexing.

In those rare cases where one is not quite sure about the sex of the specimen even after the examination of its gonads, a '?' sign may be used to indicate the situation. If due to some reason or the other sexing has not been done, a dash '—' or 'o' may be used to express that the specimen in question is unsexed.

The approximate age of the specimen may also be noted on the label, if possible. This information about a specimen is needed if it is to be utilised in a study of variation due to age. Depending on the group of mammals there are various methods of determining the approximate age of the individual. Relative body-proportions, degree of wear of the tips of canines in fruit bats and the same of the crown surface of the cheek-teeth of rodents and insectivorous bats, degree of ossification of the skull, fusion of certain sutures in the skull, etc., are some of the useful methods generally used in this connection. While no special notations are required for adult specimens, prefixes such as Suckling, Subad. (subadult), etc., may be added to the symbol for the sex. If one is sure that the specimen is not adult and is not sure about its age-group, it is better to use the notation Imm. (meaning immature) before the symbol for the sex, *e. g.*, Suckling ♂ , Imm. ♀ , Subad. ♂ , etc.

### *Measurements*

Standard measurements (in millimetres) as are applicable for the concerned group are to be noted on the label. These are not only essential in establishing the taxonomic identity of the specimen, but are also useful in studying variation due to size. Perhaps bats meant for preservation by the wet method may be exempted from this, as most of the bat workers like to take these measurements themselves from the fluid preserved specimens. Such measurements do not vary significantly from those taken before fixation.

### *Additional data on the field label*

Some further data in addition to those discussed above may increase the value of the specimen in so far as its utility in various studies is concerned. These are enumerated below.

### *Collector's number*

For each specimen collected a running serial number may be given. This number is otherwise known as the 'original number' Not all information can be noted on the label however informative it may be.

Additional information with respect to a particular specimen if required, may be obtained from the collector's 'field note book' by referring to this number.

### *Weight*

Weight (in gram) of the freshly killed animal at times is helpful in determining the reproductive state in some rodents and insectivores.

### *Mammae*

The number and position of mammae in females help in some cases to determine their taxonomic identity. A simple formula in this connection may be useful. Thus, 'Mammae :  $1+2=3$  pairs' means the total number of mammae is six (three pairs) of which one pair is thoracic and two pairs are abdominal. A further detailed formula for mammae may be like this—'Mammae :  $0+1+0+2=3$  pairs' meaning there are no axillary mammae, there is a pair of thoracic mammae, there are no abdominal mammae and there are two pairs of inguinal mammae.

### *Reproductive condition*

Reproductive conditions such as the position of the testes (scrotal or otherwise), relative size of the testes, etc., may be noted for the males. In females the condition of the vaginal orifice (open or closed), number and size of the embryos or foetuses in each of the horns of the uterus, if gravid, whether mammae are lactating (in lactation), etc., may be noted. These data furnish useful information on the seasonal reproductive condition of the specimen. Thus, if the vaginal orifice is closed, it indicates that it has not yet bred. Lactating mammae implies a nursing mother, and so on.

### *Plantar pads*

The number of plantar pads may also be helpful in some cases in determining the species. Thus, the three Indian species of the genus *Millardia* can be distinguished by the numbers of plantar pads.

### *Habitat*

A short note on the habitat from where the specimen is collected may also be written on the label, e. g., 'Trapped in a cereal godown,' 'Shot in a secondary sāl forest', etc.

*Time of collection*

If nets are set in the afternoon to capture bats and if it is possible to take out the bats as soon as they are entangled in the net, the time of capture may also be noted. The time gives some idea as to the onset of activity of the bats concerned.

*Relative abundance*

Whenever possible, the relative abundance of a species may also be noted on the label with suitable words such as 'Rare', 'Fairly common in paddy fields', etc.

When a specimen is made into a skin, its skull which is also preserved for study, should also have a label of its own. The separate label for the skull need not have to be as exhaustive as that for the skin. It would be sufficient if this label bears only the collector's number (same as that of the skin), date of collection, name of collector, and the place of collection (not necessarily the full locality). Such a label will help in correlating the skull with its skin in the laboratory.

If, however, a specimen is made into a complete skeleton, a fuller field label like that for the skin is to be written.

*Material for the field label*

As has been stated above, the field label should last as long as the specimen lasts. In view of this, the material for the field label should be of high quality.

*Quality of paper*

Parchment paper, though highly durable, gets wrinkled on standing, at least under the tropical humid conditions. The Mammal Survey used some labels made of this material for specimens preserved in formalin. All these labels are now so much wrinkled that it is practically impossible to read the data on them with certainty. Use of parchment paper for labels is, therefore, not desirable.

Any light-weight, good quality paper having 100% rag-content is perhaps the ideal material for the label. Most unfortunately, such machine-made papers are not produced in India. Good quality hand-made paper with fairly smooth surface is the nearest approach to the ideal material for the label. But handmade paper has one great disadvantage : when soaked in fluid preservatives (4% formalin or rectified spirit) it becomes soft and thereby liable to be torn off the string or

even tear into bits under the slightest stress. This paper, however, regains its toughness when fully dried. Handmade paper, therefore, is quite suitable for labels for specimens to be preserved dry, but most unsuitable for those to be preserved in fluids.

The Zoological Survey of India is using at present 'SKOLAR' brand drawing cartridge paper for labels both for dry and fluid preserved specimens. This paper, though not having 100% rag-content, appears to be quite satisfactory, at least now. Its limitations as the material for the label will, however, be known only after 50 years or so.

Incidentally, the National Museum, Bulawayo, Zimbabwe, uses 'resistal' paper for dry specimens, and 'syntosil' paper for wet specimens. It has been stated that these two types of paper are long lasting and difficult to tear (Jones, 1984).

#### *Size of the label*

A big-sized label is of disadvantage if it is to be used for small-sized specimens like *Mus musculus* Linnaeus, *Suncus etruscus* (Savi), *Pipistrellus mimus* Wroughton, or *Tylonycteris pachypus* (Temminck). At the same time a label of very small size does not have sufficient space to enter all the required data on it. A rectangular piece of paper, 8 cm in length and 2 cm in breadth appears to be the optimum size for a field label for a mammalian specimen.

#### *String*

Not only the paper for the field label should be durable, but the string to tie it to the specimen should also be so. Ordinary cotton threads of various counts have been used for field labels in various institutions, including the Zoological Survey of India. Even jute thread has found its use for the preparation of field labels ! Considering the durability factor, these threads are to be taken as unsuitable. For the last several years the Zoological Survey of India is using mercerised cotton thread (No. 8) for field labels. Even this may not be quite durable under the tropical conditions. The Zoological Survey of India is now actively searching for a better substitute. Silken thread, nylon thread, and any other synthetic thread are much more durable. But with such threads the knot cannot be tightened. Perhaps, real linen thread (No. 8, approximately 0.5 mm thick) may be a better substitute.

#### *Metal eyelets vs punch*

Metal eyelets, either one central or two lateral, at one end of the label, as are used in some institutions for the insertion of the string, are

detrimental for the label. These eyelets, made either of iron or of brass, with the passage of time develop rust/verdigris which corrode both the paper and the string. Therefore, use of metal eyelets on the label is not desirable.

A medium-sized sewing needle with the desired string passing through its eye is better used for the insertion of the string through the label.

### *Writing of the field label*

Needless to say that the permanency of the field label becomes useless if the entries on it become faded and impossible or difficult to read. Many of the field labels of fluid preserved specimens collected by the Mammal Survey have thus become practically useless. Therefore, the ink to be used for writing the field label should be selected with utmost care. Obviously it is to be such that it leaves a permanent impression on the label. Ordinary fountain pen inks are unsuitable for this purpose as most of them are completely washable while some leave but a faint impression on the label, when washed with water. Ball pen inks are soluble in rectified spirit. It even spreads out on paper with the passage of time. Its use on the label is, therefore, not desirable.

Waterproof drawing ink such as the India ink can be used for field labels. 'Rottringer'-type of pens with their ink (which is waterproof) can also be profitably used for this purpose, under certain conditions.

Even waterproof inks like the India ink and the others as mentioned above are at least partially washable if the label is immersed in fluid preservatives immediately after writing. Such inks really become waterproof only if the writing is allowed to dry for several hours. This, therefore, makes these inks unsuitable for writing field labels for wet specimens, for a mammal already dead for some hours cannot wait for several hours under the tropical humid conditions only because the ink on its proposed label is not yet properly dried.

If, however, field labels are written with good quality lead pencils, such labels can be immediately and safely used for specimens to be preserved by any method. Depending on the surface and hardness of the paper, H, HB or B grade of lead pencil is to be selected so as to make the writing quite prominent.

It is desirable that the collector himself writes the field label. In mixed collecting parties, a non-mammalogist may procure an example of mammal. The field label for such a specimen is also to be written by the mammalogist of the party. He, in such a case, naturally has to de-

pend on the person who has actually procured the specimen, regarding some of the field data. When a specimen is donated to the collecting party or when a specimen is purchased locally, the field label for such a specimen also is to be written in the same manner.

Some collectors may not have good handwriting, but if all the entries on the field label are made clearly and legibly, preferably in separate letters instead of running ones, the purpose will be fully served.

#### INSTITUTIONAL LABEL

In the laboratory, after a specimen is properly identified and registered, an insitutional label, otherwise known as the 'museum label', is generally added to the specimen. An institutional label is generally a printed one and bears the name of the institution. It has also space for making entries like the institutional registration number, scientific name, locality, name of the collector, date of collection, collector's number, sex, etc. All these entries except the first two are naturally copied from the field label. On the other side of the label are also copied from the field label the data regarding the external measurements, weight, etc. Utmost care should be taken while transferring the field data on the institutional label to avoid any possible error in doing so.

In many institutions, especially those maintaining collections from different countries of the world, the locality is entered on the institutional label in a centripetal manner, *i. e.*, the name of the country comes first, then those of the state and district in that sequence, and finally the name of the place from where the specimen was collected, *e. g.*, 'India, Orissa, Koraput district, Kashipur' In other institutions, including the Zoological Survey of India, where collections are mostly from one country only, the centrifugal method is followed in entering the locality, *e.g.*, 'Kashipur, Koraput district, Orissa'

Both the systems are equally good. But it is desirable that the geographical co-ordinates of the exact locality, as far as practicable, are noted on the institutional label after the name of the place. This will help in locating the place easily even if one is not conversant with the names of districts, states, etc.

A separate institutional label is also to be written for the skull. This label may bear only the registration number, scientific name, locality, the name of the collector, collector's number, date of collection and sex. It is desirable to write the registration number on the dorso-lateral aspect of the cranium and also on each of the ramii of the lower jaw, with permanent ink.

The quality of the paper and the size of the label can be the same as those of the field label, but the entries should always be made only with permanent ink (India ink or some similar ink).

One final word of caution in connection with labels : the original label, under any circumstances, should never be replaced with any other label. The institutional label is to be tied to the specimen in addition to the original label. If the original label is partially damaged, a copy of the same may be made and this additional label may also be tied to the specimen but the partially damaged original label should never be removed.

If a specimen is obtained as a donation or by exchange from some other institution and bears an institutional label, the same should not be removed, only an institutional label of the recipient institution should be added to the specimen. This will subsequently help in tracing the history of the specimen.

#### SUMMARY

The importance of proper labelling of mammalian specimens can perhaps never be overemphasised. If a specimen is to be utilised in modern taxonomic research, it should have at least some essential data such as the exact locality from where the specimen was collected, the date of collection of the specimen, its sex, approximate age and various external measurements, etc., clearly depicted on its field label. Some additional data, namely the weight of the freshly killed animal and notes regarding its reproductive condition, habitat, relative abundance in the collecting area, etc., on the field label, make the specimen more useful in the present-day taxonomic studies. The procedure for entering these data in the field label is discussed. As the field label is expected to last as long as the specimen, the material for the label should be highly durable. Selection of the paper, string and the ink for the field label are discussed. The procedure for the writing of the institutional label is also mentioned.

#### REFERENCES

- DOBSON, G. E. 1976. Monograph of the Asiatic Chiroptera, and catalogue of the species of bats in the collection of the Indian Museum, Calcutta. Indian Museum, Calcutta ; Taylor and Francis, London.
- JONES, E. 1984. Problems of maintaining large collection of mammals in a developing nation : National Museum of Zimbabwe.



*Abstr. Proc. Wksp. Mgmt. Mammal Colln. tropical Environ., Calcutta : 37-38.*

SINHA, Y P. 1977. Taxonomic status of *Megaderma spasma majus* Andersen (Chiroptera : Megadermatidae). *J. Bombay nat. Hist. Soc.*, 74 : 156-157.

WILLIAMS, S. L. LAUBACH, R, and GENOWAYS, H.H. 1977. A guide to the management of Recent mammal collections. *Carnegie Mus. nat. Hist., Spec. Publ.*, (4) : 105 p.

#### DISCUSSION

- Q. What is the quality of your label-paper ? Is the paper stock that you use for skin-labels the same as used for tags or labels of fluid-specimens ?
- A. We use 'Skolar' brand drawing carriage paper both for the dry and fluid-preserved specimens.
- Q. Why not catalogue all current localities with the exact location documented on maps for future reference?
- A. The best method of determining a collection site is to have the geographical co-ordinates.
- Q. Please provide the type of ink used for labelling. Is it used for labelling all tags for dry and fluid-preserved specimens?
- A. Lead pencil is used for field labels and 'Rottringer' pen and ink for museum labels for both dry and fluid-preserved specimens.

## ACCESSIONING AND CATALOGUING

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### INTRODUCTION

A good system of documentation serves as the memory of a museum. Long after individual curators have come and gone, the records of the museum will provide the necessary information about the collections. Good records will greatly enhance the value of the collections, and poor records will surely detract from that value.

Curating a collection of mammals carries with it the obligation to maintain the collection in as good a condition as possible, and to maintain and add to the information about the specimens thereby providing a complete historical track of their use and treatment. Good documentation for a collection is simple to acquire, and impossible to replace.

The operation of a museum carries with it a public trust. There is an unstated rule that the museum with all of its contained collections will endure in perpetuity. This durability of the collections is one of the most important reason to maintain an accurate and complete system of documentation.

The museum community has evolved a general system of documentation or registration of collections over the years. There are many variations on the general theme, but almost all museums use some parts of the general scheme described herein.

In general, the registration process includes two separate processes : accessioning and cataloguing. Accessioning makes a record of the reception of specimens into a museum's control. Cataloguing makes a record of data for each individual specimen.

### ACCESSIONING AND ACCESSION RECORDS

An accession consists of one or more specimens received from one source, usually at one time. Specimens may be acquired in several ways. Permanent acquisitions may come as gifts, purchases, field collections of museum staff, or exchanges. Normally, only permanent acquisitions will

be accessioned, but also it is possible to use your accession system to track material coming in on loan or received for identification.

A simple but effective accession system might consist of three kinds of record keeping devices : an accession ledger, a card file of donors, and a file of accession paperwork.

The accession ledger provides a chronological record of all incoming material. The ledger should be bound, and should contain low acid, high rag content paper to ensure permanance. An alternative might be to use preprinted forms that can be inserted into a typewriter, or generated by machine (computer or word processor), then bound in lots of standard size (200-500) as they are accumulated. Until permanently bound, the loose sheets should be temporarily maintained in ring or post binders, because loose sheets are too easily lost. In general, entries should be made into the accession ledger as soon as possible after receiving an acquisition. Entries should be made with permanent ink and normally should occupy a single line of the ledger.

Two common systems of numbering accession records are used today. The simplest of these is a chronological series of number beginning with one for the first accession and continuing with the next number *ad infinitum*. Each accession gets a single number, whether it be a single specimen, or several thousand specimens.

An alternative system is to use the year as a prefix and to then use a sequential series for all of the accessions of a given year. Using this system, for example, the first accession of the year 1983 might be numbered 1983/1 or 983/1 or 83/1. Using a two digit number for the year (83) is not useful if your collection has been in existence since 1883 or if you think it will be round in 2083. Naturally, we all expect our collections to be around for another 100 years, so it is preferable to use a three or four digit number for the year. The only advantage to using the four digit number is that it is more readily understandable, even to someone who is otherwise unfamiliar with your system. The general advantage to the date/accession system is that the number alone conveys some information about the accession, namely, the year in which it was entered into the museum collections.

The ledger should contain columns for the following information, as a minimum, and might have others to suit your particular needs : number, date received, donor name and address, description of accession, including estimate of number of specimens, how acquired, and remarks.

Use the remarks column to note any pertinent facts such as damage, missing specimens, loss, special instructions, or other potentially useful

data. Occasionally, collections may be donated with “conditions” attached : The material must be exhibited, or must bear the donor’s name, or may not be exchanged without notifying the estate of the donor. The remarks column can be used to note these conditions or to note that the details are in the accession file. Also, you might want to use the remarks column to record the catalogue numbers assigned to the accession, once the specimens are catalogued individually.

The second part of the accession record is a donor file. Probably this is most easily kept as a card file, with a separate card for each accession, filed alphabetically by donor or source. Each time an accession comes in, a card should be completed including at least the name and address of the donor, and the accession number. Then if someone wants to know about the objects from a particular source, all they have to do is to look up the name of the donor in the card file, read the accession number(s), then look up the number(s) in the accession ledger. The accession ledger, in turn, will provide further information, such as the catalogue numbers of the objects in that accession, by which information on specific objects can be retrieved.

The third kind of accession record is the accession file. All the paperwork for each accession should be put into a file folder or large envelope and filed in numerical order in a standard file cabinet. This paperwork might include such things as correspondence, letters of acknowledgment, receipts, shipping papers, damage reports, itemised lists, collecting permits, and other documents relating to the transaction.

It might be useful to have a checklist form to fill out for each accession that specifies the individual steps that need to be taken to process the material. An important part of the checklist should be to acknowledge receipt of material to the donor. The checklist can then form the first page in the accession file.

Before completing the accession paperwork, the specimens should be fumigated to avoid any possibility of contamination of material already in the collection. If any or all of the accession is not going to be catalogued immediately, you will need to temporarily store the specimens, and if you are using a worksheet form, it should be kept with the accession to help identify it until cataloguing is completed.

A quick summary of the accession process up to this point might include : Receive the material, unpack it, look at it closely enough to determine what it is and about how many specimens there are, enter it into the accession ledger, and fumigate the specimens. Filling out a donor card, putting any associated paperwork in the file, and “fine tuning” the

records in the ledger can take place next or as additional information about the acquisition becomes available. Then the collection can be put away in a temporary storage case along with some kind of identification including the accession number.

### CATALOGUING

The second major process in the registration system is cataloguing. The accession records refer to a transaction, but the catalogue record refers to an individual specimen. Each specimen in an accession will receive its own unique catalogue number. This number can then be used to refer to that specimen in publications or reports forevermore. Catalogue numbering systems can be selected to match the accession system. If you use the simple numerical sequence for accession numbers, then it is probably best to use a simple numerical sequence for the catalogue as well. However, the catalogue numbers will be a completely different sequence than the accession numbers. For instance, the first accession you have, accession number 1, might consist of 398 specimens. Each of those 398 specimens will receive a separate catalogue number, so that the catalogue numbers pertaining to that accession will be 1-398.

The alternative system, already discussed, was to use the year to form the first part of the accession number. If this system is used, it can logically be extended to include the catalogue number. In our example then of the first accession for 1983, the accession number was 1983/1. If that accession consisted of 398 specimens, then individual catalogue numbers could be assigned as 1983/1/1, 1983/1/2.....1983/1/398. The 28th accession for 1983 then would be written 1983/28 and the individual specimens would receive catalogue numbers 1983/28/1 though however many specimens make up the accession.

The catalogue itself may be in the form of a ledger, a card file, or a multipart form that can be bound or filed in various ways. Traditionally, mammal collections have used bound ledgers as their catalogues, but nowadays, with computer cataloguing becoming more popular, a variety of systems are in use. Regardless of the system, the permanence of the catalogue should be stressed. The catalogue number, written on or attached to the specimen itself, is the key to all associated information about the specimen.

To be able to associate information permanently with specific specimens, we assign each a catalogue number. This number stands for one specimen and one specimen alone. Each specimen receives its unique number as it is entered into the catalogue. The number should be written both in the catalogue and on the specimen or on a tag attached to the

specimen. The number can be written directly onto skulls and individual bones in permanent ink. Each study skin should have an individual label attached to it, and the museum catalogue number can be written on that label.

However applied, the number should be easy to find, clearly legible, durable, and must not interfere with the study of the specimen. As a rule, the number should be placed in the same place on all labels, or written in the same place on all skulls and bones.

The catalogue itself should contain the following columns as a minimum : catalogue number, accession number, original number (field number), scientific name, locality, date collected, donor, collector, date catalogued, sex, nature of specimen (skin & skull, fluid preserved, skeleton only, etc.), and remarks. Each of these entries should be completed for each specimen in an accession. All entries should be made in permanent ink except for the scientific name, which may need to be changed from time to time based on re-identifications or nomenclatorial changes.

If a large accession is being catalogued, it is preferable to arrange the specimens in an orderly fashion before entering them into the catalogue. One such logical arrangement is as follows : phylogenetically to genus, then alphabetically by species, then by locality, then by date, then alphabetically by collectors name, then by collector's field number. By entering large collections into the catalogue in a prescribed order, it makes it easier to locate information about a particular specimen when not all of the data are known about it.

Additional types of catalogues can be maintained according to your particular needs. Because the museum catalogue is arranged numerically by catalogue number, it is sometimes useful to have card files arranged by species or locality. These can be generated as part of the cataloguing process, or at a later date as time permits. If a multipart form is used for the cataloguing process, the top copies should be bound as the museum catalogue, and then the other copies can be filed in the ancillary files.

To summarise the cataloguing procedure, arrange the specimens of a particular accession in a logical sequence, assign and affix a number to each, enter the data into the catalogue, and prepare any additional catalogue files as necessary. A list of the catalogue numbers can then be entered into the accession records, and the specimens are ready for installation into the collection, if all parts are cleaned and ready, or can be returned to temporary storage to await cleaned skulls or skeletal material if necessary.

If the specimen consists of more than one part, such as skins and skulls, then the catalogue number must be written on, or attached to, all parts. Uncleaned skulls should have a field tag attached, and the catalogue number can be written on that tag, which should then remain with the skull throughout the cleaning process. Once cleaned, the number can be written on the skull itself with permanent ink.

Once all associated parts of a specimen are reunited, the material can be installed into the main collection for future study and use. It is during such studies that it frequently becomes necessary to obtain all available information about one or more specimens. Having reviewed the accessioning and cataloguing process, I now examine some examples of how those information systems might be useful.

Assume that a visitor has located a particular specimen in the collection and wants to know more about it. First of all, you can check the catalogue number on the specimen, and then refer to that number in the museum catalogue. The catalogue itself contains several items of information about the specimen, and gives you an additional number to refer to : the accession number. Using the accession number, you can refer to the accession ledger and the accession file for information on where the specimen came from and how it got there.

Another possibility might be a request from someone who wants to know what happened to the material Dr. Jones donated a long time ago. By going to the donor file and looking under Jones, you can read the accession numbers of his donations. You can then look up the appropriate accession in the accession ledger, which will tell you if the material is still in the collection or perhaps has been exchanged or transferred elsewhere. You can also find the catalogue numbers of the material in that accession, and a quick look at the museum catalogue will give you additional information about the specimens.

Additional catalogue files can be used to answer a variety of information requests such as : How many specimens of *Cynopterus sphinx* do you have ? If a species card file is maintained, it can be consulted to obtain the necessary information. Often, requests are for information on the number of specimens from a particular geographic locality, such as a province, state, or country. If a geographical card file is maintained, this type of information is readily available.

#### SAMPLE PROCEDURES FOR HANDLING INCOMING SPECIMENS

As an example of how an actual system of accessioning and cataloguing works, the detailed instructions for handling incoming specimens received by the Museum Section, U.S. Fish and Wildlife Service, at the

U.S. National Museum of Natural History are presented here. This is not necessarily the ideal system for every museum, and you will want to tailor your particular system to the needs of your museum.

Incoming new specimens are unpacked and then logged into the "Catalogue of Specimens Received," or accession ledger. This ledger provides an accession number for the collection and acts as the first step in the accession process. General information concerning the collection is entered in the ledger (Fig. 1). A "Specimens received" data sheet (Fig. 2) is then filled out in greater detail. This data sheet will remain with the collection until the specimens are installed in the main collection. A "Donor Card" (Fig. 3) is completed and filed immediately. Dry specimens are then fumigated with liquid Dowfume for a minimum of 3 days. If the specimens were received from an outside source (someone not employed here) a letter is written acknowledging receipt of the collection. In preparation for cataloguing, the specimens are identified to species (if possible) and arranged phylogenetically to genus following Simpson (1945). After genus, the specimens are arranged alphabetically by species, then by locality, date and collector's number. If there is more than one collector within each locality and date, the collector's names should be arranged alphabetically. The specimens are then arranged numerically by collector's field number.

When the skins are in order, all other parts to each specimen are placed with the appropriate skin. Skeletons are inserted in proper sequence among the skins but alcoholic specimens are usually kept separate and catalogued after the dry material, following the same arrangement as used for the dry specimens.

Copies of all field catalogues, notes, and permits are obtained and they remain with the collection during processing, as well as correspondence and miscellaneous notes.

All cataloguing is done in permanent ink in a museum catalogue. A copy of a catalogue page is attached (Fig. 4), which shows the types of data entered. The only information not entered in ink is the scientific name, which is written in pencil.

One specimen is catalogued at a time. For dry specimens, the catalogue number is written in permanent ink on the front of the skin tag and on every other tag associated with any part of the specimen (Fig. 5). Skin tags on wet specimens must be dried before this can be done. An embossed label with the catalogue number is also added to fluid specimens. The catalogue number series for the collection is entered in the "Final Disposition" section of the Specimens Received data sheet and individual catalogue numbers may be entered in the field catalogue by their corresponding field numbers.



BS number	Date received	Donor Name & Address	Description of Material	Type of acquisition	Remarks
BS-146	11 June 1981	Eric O. Forsman 4855 NE Elliott Creek Carroll, OK 73330	15 sets of bat remains from owl pellets	scattered	returned to sender Ethan sold
BS-147	1 July 1981	Phillips, Craig Tanna 1009 Grant Ave Silver Spring, MD	Frozen <u>Desmodus</u> <u>marcupoli</u> from MD	donation	household pet 22 Jun 1981
BS-148	16 July 1981	Stromberg, M R Wyoming Natural Heritage Program Cheyenne, WY 82001	2 sps of <u>Myotis</u> from Wyoming (skins & skulls)	donation	from AZO NM
BS-149	14 July 1981	Wilson, D F Museum Section Nat'l Mus of Nat Hist Washington DC 20560	235 skins skull skeletons alics of <u>Sorex</u> <u>marcupoli</u> & <u>harpax</u>	field collection	
BS-150	4 Aug 1981	Rowlett, Richard A 13425 Reid Circle Ft Washington, Md 20022	misc skin & skulls & few humps	donation	
BS-151	2 Sep 1981	Whitney, V L 633 S Berry Pine Road Rapid City, South Dakota 57701	1 frozen <u>Spermophilus</u> 1 frozen <u>Procyon</u> from SD	donation	
BS-152	4 Sep 1981	Jac Marshall Museum Section National Museum of Natural History, Wash DC	4 <u>Myotis</u> skin & skull from Newfoundland		
BS-153	8 Sep 1981	D V Lanning P.O. 836, Douglas AZ	3 <u>Thomomys</u> & 1 <u>Uta</u> skin & skull from AZ		
BS-154	7 Oct 1981	Wilson, D E Museum Section, Nat'l Museum of Natural History Washington, DC 20560	~400 misc skin, skulls, skels & alics	field collection	Noyant NY
BS-155	9 Sep 1981	Lekeguel, B Association for the Conservation of Wildlife 404 Custom House Lane Bangkok 8, Thailand	7 <u>Uiventer</u> skins & skulls from Thailand	donation	
BS-156	Sep 1981	Brook, C 6425-116 Field Station 412 NE 16th Ave, Rm 250, Fla 32601	2 <u>Trichogloss</u> <u>marcupoli</u> skeletons, 1 from Puerto Rico	field collection	
BS-157	26 Oct 1981	Manski, D National Park Service, Wash, DC	1 frozen <u>Castor</u> <u>canadensis</u>	donation	DOR
BS-158	29 Oct 1981	Foster, M Division of Birds, USFWS National Museum, Washington DC	4 bats from Paraguay	field collection	
BS-159	4 Nov 1981	Lanning, D V PO 836 Douglas AZ	3 bats, 13 rodents (skins, skulls, skels, alics)	donation	
BS-160	23 Nov 1981	Hoogstraal, H US Naval Medical Research Unit No 3 Medical Zoology Department, FPO NY 09527	11 skins & skulls & skeletons of <u>Mus</u> <u>domestica</u> & <u>M. musculus</u>	donation	
BS-161	30 Nov 1981	Thorington, R W Mammal Division Nat'l Mus, Nat Hist, Washington, DC 20560	1 skull fragment & 1 skull skel. fragment of <u>Notiosorex</u>	donation	taken from Great Horned owl pellet
BS-162	14 Dec 1981	T French Cornell University, NY Coop Wild Res Unit, Ithaca, NY 14853	1 skull of <u>Sorex</u> <u>dispar</u> from Maine	donation	Amesbury
BS-163	22 Dec 1981	Emmons, L H Nat'l Mus Nat Hist, Washington, DC 20560	11 skins skulls & 2 alcoholic specimens & rodents		
BS-164	12 Feb 1982	Manski, D National Park Service, Wash DC Museum Section NMNH	1 red fox Redd kill from Md		
BS-165	19 Feb 1982	Wilson, D E Washington DC 20560	22 mammal specimens from Paraguay	field collection	
BS-166	23 Feb 1982	Fritts, T H FWS, DWR Tulane Univ Mus of Nat History, Belle Chasse, LA	skull of <u>Mephitis</u> <u>mephitis</u>	field collection	
BS-167	10 Mar 1982	Barkalow, F S Jr. Box 557 North Carolina State University, Raleigh, NC	1 <u>Tamias</u> <u>marcupoli</u> <u>hudsonicus</u> skull & 1 <u>Melospiza</u> skull	donation	
BS-168	12 April 1982	Davis, Wayne H Department of Biology, University of Kentucky, Lexington, Ky 40506	1 <u>Plecotus</u> <u>townsendii</u> <u>virginianus</u> skin, skull, skull skel	donation	redesigned specimen enclosed - low enhancement restored
BS-169	April 1982	Emmons, Louise Division of Mammals USNM	3 skulls of <u>S. Am</u> rodents	donation	skins to room taken rec'd 14 Jul 1982
BS-170	21 Apr 1982	Bogan, M A DWR Fort Collins Field Station, 1300 Blue Spruce Dr 80524	334 mammals from Bay, a Cal fauna, Mo	field collection	
BS-171	30 Apr 1982	French, T W New York Coop Wildlife Research Unit Dept Nat Resources, Forest Hill, Ithaca, NY 14853	55 mammals, from 16 Catskill Mts, NY	donation	
BS-172	3 May 1982	George, T K 610 S South Second St Dorsey, IL 62230	bat skulls from owl pellets from Mar 1		sent to ALG for identification
BS-173	4 May 1982	Urbano V Guillermina Instituto de Biología, Dpt Zoología Lab. Mastozoología, Apartado Postal 70-253, Merida 20, DF.	18 bat skins & skulls & 1 rodent skin & skull from Chiapas	donation	
BS-174	113 May 1982	Janzen, D H.	1 alcoholic skin & removed skull of <u>Oryzomys</u> <u>pachetris</u>	donation	

Fig. 1.—Accession ledger.

SPECIMENS RECEIVED  
MAMMAL SECTION  
NATIONAL FISH AND WILDLIFE LABORATORY

File No.: BS 149Date received: 14 July 1981Nature of Material: 235 skins, skulls, skeletons and alcoholics of small  
mammals and herps from Arizona and New MexicoLocality: Arizona Cochise Co. and  
New Mexico Hidalgo CoWhen collected: 24 Mar-9 July 1981  
How obtained: field collection  
Field notes: —  
Field catalog: ✓  
Permits: —Received from: Wilson D.E  
Address: Museum Section- Nat'l Fish & Wildlife Lab  
National Museum of Natural History  
Washington, D.C. 20560Collector: Don E. Wilson, D.V. Lanning and T. Steirboff

Remarks: \_\_\_\_\_

Final Disposition: USNM catalogue #S 552744-552928Date of Entry: 14 July 1981Entered by: C.A. Ramotnik

Letter written to donor: \_\_\_\_\_

Fig. 2.—Specimens received data sheet.

DONOR CARD  
MUSEUM SECTION - MAMMALS  
NATIONAL FISH AND WILDLIFE LABORATORY

Name: *Wilson, D E*

File No. BS -149

Address: *Museum Section  
National Fish & Wildlife Lab  
National Museum of Natural History  
Washington, D.C 20560*

Date Received: *14 July 1981*

Phone: *202-357-1920*

Description of Material: *235 skins, skulls, skeletons and alcoholics of small mammals  
and herps from Arizona and New Mexico*

Type of Acquisition: *field collection*

Filed by: *C.A. Ramotnik*

Date: *14 July 1981*

Fig. 3.—Donor card.

Catalog No.	Accession No.	Original No.	Name	Locality	When Collected	Received From	Collected By	When Examined	Sex and Age of Spec.	Remarks
311278		DEW 5207		Arizona Cochise Co San Bernardino Ranch	8 Jul 1981	BS 149 D E Wilson	D E Wilson	31 Jul 1981 CAR	♀	skin and skull
		DEW 5208							♀	
		DEW 5100			2 Jul 1981				♀	
		DEW 5109			8 Jul 1981				♂	
311279		DEW 5161			2 Jul 1981				♀	
		DEW 5210			8 Jul 1981				♀	
		DVL 44			10 Jan 1981		DV Lanning		♀	
		DVL 22		Arizona Cochise Co San Bernardino Ranch R30E, T24S, 31W	13 Apr 1981				♀	
		DEW 524		Arizona Cochise Co San Bernardino Ranch	8 Jul 1981		D E Wilson		♀	
		DEW 5227			6 Jul 1981				♂	
		TS 252		Arizona Cochise Co San Bernardino Ranch 16 m E Douglas R20E, T24S, 31S	13 Apr 1981		T Stierhoff		♂	
		TS 253							♂	
		DEW 5169		Arizona Cochise Co San Bernardino Ranch R20E, T24S, 31W	3 Jul 1981		D E Wilson		♀	skull and skeleton
		DEW 5170							♂	skin and skull
311276		DEW 5171							♀	
		DEW 5172							♀	
		DEW 5173							♂	
		DVL 31		Arizona Cochise Co San Bernardino Ranch, 16 m E Douglas R20E, T24S, 31W	13 Apr 1981		DV Lanning		♂	
		TS 261					T Stierhoff		♀	
		DVL 5		Arizona Cochise Co San Bernardino Ranch R30E, T24S, 32S	10 Mar 1981		DV Lanning		♀	
		DVL 13		" R30E, T24S, 34					♂	
		DVL 17		" R30E, T24S, 31W	8 Apr 1981				♀	
		DVL 20			9 Apr 1981				♂	
		DVL 26			13 Apr 1981				♂	
311277		DVL 27							♀	

Fig. 4.—Museum Catalogue.

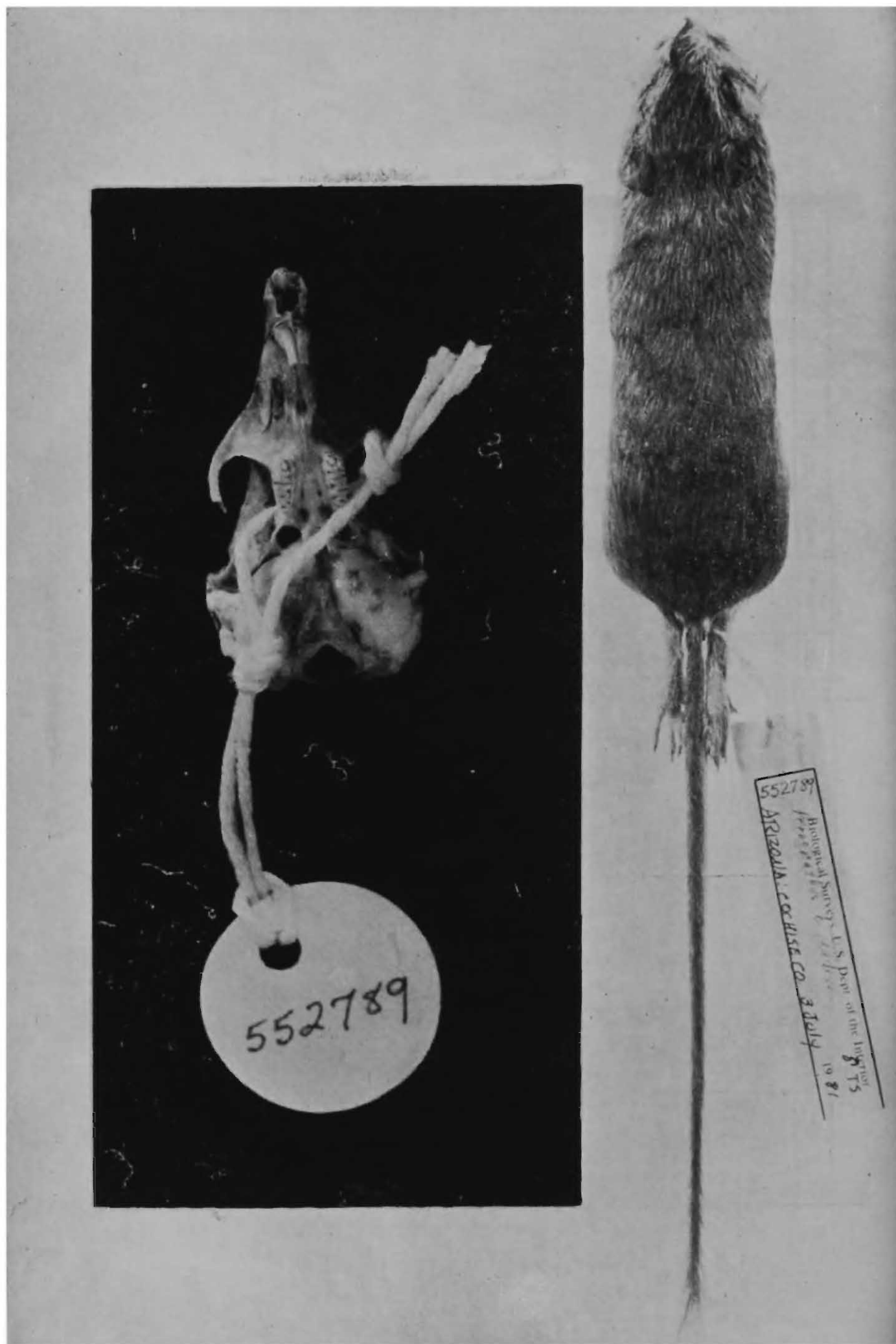


Fig. 5.—Skin and skull tags.

Uncleaned skeletal material is separated immediately after cataloguing and sent to the osteological preparation facility. The skins are held separately from the main collection while skeletal material is cleaned. Alcoholics are either held up for research purposes or prepared for installation into the collection.

Skeletal parts of specimens are taken to the dermestid beetle chamber and placed in individual containers (small boxes and egg cartons), which are then placed in a larger "bug box". Dermestid beetles may be gathered from other "boxes" if an insufficient number are present. The specimens should be checked after a couple of days to see how they are doing. More beetles can be added if needed. Specimens should be removed from the bug box as soon as they are clean to avoid damage to cartilage and labels. It is important to use durable skull tags that will not be eaten by the beetles, even if they become bloody or greasy.

As the specimens become cleaned and free of flesh, they are placed in individual covered boxes and removed from the dermestid chamber. The boxes containing the cleaned material are then fumigated for 3 days.

After being fumigated, each specimen is soaked in an individual jar of warm 10% ammonia solution for 3-4 hours, drained, and soaked in water for 1-2 hours. These times vary depending on the size of the specimen and how clean of flesh it is. Each specimen is then hand cleaned with picks, forceps, or any other tool that allows safe removal of any remaining flesh. Tags are not soaked but are left hanging outside the soaking container. The tag string is removed from the tag after the bones are cleaned. The tag is placed with the specimen while it dries in an open container, usually a box or egg carton. The specimens are allowed to air dry in the drying room until completely dry, usually 3-5 days.

Dry specimens are then placed in vials or boxes. If they are not completely dry before being placed in a closed container, mould will form. The material is then fumigated for 3 days.

The skeletal material is now ready to be numbered. One at a time, each skeleton or skull is removed from its vial or box and the catalogue number is applied with permanent ink from a steel pen to every bone or fragment possible. The sex of the specimen is also applied to the skull or largest piece of the skull. On the skull the number is written on the cranium from front to back with the sex symbol applied above the number (Fig. 6).

Labels are then typed (or computer generated) and inserted into vials or boxes as appropriate (Fig. 7). Large skulls are labelled with museum tags tied to the right zygomatic arch, if possible, and usually are not boxed or labelled otherwise.



Fig. 6.—Skull numbering.

BIOLOGICAL SURVEY  
UNITED STATES NATIONAL MUSEUM  
F 525297 I

MYOTIS PENINSULARIS  
MEXICO: BAJA CALIFORNIA SUR  
SIERRA LAGUNA, CANON OJO DE AGUA, 3 KM E  
LA BURRERA

520 M 20 NOV 1977  
BGGAN, M. A. 2278

7 (a)

## BIOLOGICAL SURVEYS COLLECTION

No. 552789 M Date 3 Jul 1981  
Name *Perognathus baileyi baileyi*  
Arizona: Cochise Co.  
Loc. San Bernardino Ranch  
Col. D.E. Wilson 5170  
National skin & skull Museum.

7 (b)

Fig. 7. (a) (b)—Skull vial or box labels.

Skeletal material is then matched with corresponding skins. Final identifications of the specimens are made and the names are written on labels and tags in pencil.

A letter is written to the donor thanking him or her for the collection, providing the museum catalogue numbers assigned to the collection, and indicating final identification. Occasionally the museum catalogue is copied and sent to the donor. The "Specimens Received" data sheet is then copied. One copy is placed in the "Specimens Received Data Sheet" file, which is organised by year and file number. The other copy is placed with all of the correspondence, field catalogues, permits, notes, etc. that pertain to the accession and is filed in the accession file which is also arranged by year and file number.

Several segments of the collection have been data processed. Each case of specimens for which this has been completed is marked to indicate such and no specimens are installed until a computer data sheet (Fig. 8) has been completed and returned to the Automatic Data Processing office. North American specimens (Panama north) that will go into segments of the collection that have not been data processed must be "carded" before installation. This is a process of recording the specimen data on cards (Fig. 9) that will be added to the phylogenetic-geographic card file.

The specimens are now ready to be installed in their appropriate place in the collection. The collection is arranged phylogenetically to the generic level following Simpson (1945), then alphabetically by species, subspecies, country, and state and numerically within state. The curatorial locality cards in each tray should be updated, and drawer and case labels corrected where necessary. The geographic file cards are installed as the final step.

#### THE USE OF COMPUTERS IN THE REGISTRATION PROCESS

Computer usage is increasing rapidly in all segments of society including museums. In addition to making possible research applications that were virtually impossible a few years ago, automatic data processing has proved a great boon to the curation of collections. Although the details of completely machine processed accessioning and cataloguing systems are beyond the scope of this paper, it should be pointed out that every step of the documentation, registration, and paperwork processes can be efficiently converted to computer processing if the resources are available. A Bibliography on "Computers in the Museum" was compiled in June 1983 by Catherine D. Scott and Caroline L. Shugars of the Smithsonian Institution. Copies may be obtained by writing to : Ms. Catherine D. Scott, Chief Librarian, Museum Reference Center, Office of Museum Programmes, Smithsonian Institution, Washington, D.C. 20560.





Perognathus baileyi baileyi

Arizona Cochise Co.

San Bernardino Ranch

552786	♀	13 Apr 1981	T Stierhoff	252	skin & skull
552787	♂	"	"	253	"
552788	♀	03 Jul 1981	DE Wilson	5169	skull & skeleton
552789	♂	"	"	5170	skin & skull
552790	♀	"	"	5171	"
552791	♀	"	"	5172	"
552792	♂	"	"	5173	"

Fig. 9.—Card for Phylogenetic or Geographic File.

## CONCLUSION

Accessioning and cataloguing are the two processes that allow for complete documentation of the history of each specimen in the collection. The accession system, consisting of three kinds of records, an accession ledger, donor file and accession file, contains documentation for each acquisition, whether it consists of a single specimen or many. The accession records contain information on when, how, and from whom incoming material was obtained.

Cataloguing is the process whereby information is recorded for each individual specimen in an accession. An individual, unique catalogue number ties each specimen to all associated data. A minimal cataloguing system consists of a single ledger or file, arranged numerically by catalogue number. Additional files, arranged phylogenetically or geographically, or specifically designed for individual needs, may be added to the cataloguing system.

Additional information on these topics can be found in Agrawal (1974), Barcaw (1975), Borgstede (1974), DeBorhegyi (1958), Dudley *et al.* (1979), Guthe (1970), Reibel (1978), Ross (1972), and Williams *et al.* (1977).

## SUMMARY

If the first obligation of a museum is to build and maintain good collections, then surely the second obligation is to maintain accurate and orderly records, without which the collections would be of little value. Records provide documentation for each specimen in a collection and for each collection in a museum. Accurate records permit present and future users to obtain maximum information about each specimen. When a specimen is added to the collection, therefore, complete information on it must be obtained from the donor and collector.

Accessioning may be defined as the registration of one or more specimens from a single source, and usually at a single time. Cataloguing is the registration of information relating to each individual specimen in an accession. The registration process, then, normally includes the assignment of two numbers : an accession number for the group of specimens that make up the accession, and a catalogue number for each individual specimen.

There are several kinds of information records or files, each serving a particular purpose or need. Commonly a museum will have an accession

file, which may be a bound ledger or a card file. This file is usually arranged numerically. It describes the entire accession and provides information to answer the questions : What is the material ; when and how was it obtained ; and from whom was it received ? A museum might also have a separate donor (or source) file, normally arranged alphabetically by the name of the donor, and bearing information about the source, including a complete list of previous accessions from that donor. Another important file is for accession documents. This is an open-ended file folder or envelope system where all manner of supporting documents for the accession may be kept. These supporting documents include but are not limited to : transaction records, correspondence, news clippings, donor's or collector's written records, publications or references thereto, photographs, research reports, and field notes. Material may be added to this file at any time.

Apart from these three kinds of accession records, there is a catalogue in which to record the complete description of each specimen including an individual, unique, catalogue number. The numbering system can be any one that seems efficient for your particular operation. By far the most common is a simple numerical sequence beginning with the number one for the first catalogued specimen and continuing indefinitely. Another system used is a three-part number indicating the date catalogued, accession number, and specimen within the accession. This system also provides a unique number for each specimen. The date/accession/specimen system might yield a number such as 938/56/12, indicating specimen 12 in accession 56 in 1938. Regardless of the system used, each specimen in the collection should bear a unique number, either written on it or attached to it and for each specimen there will be one or more written records bearing this same number. Additional information files, such as those based on locality or phylogeny, may be kept if separate records with this information meet a particular need.

Just as the specimens have to be kept safe and secure, the records also should be maintained in a safe, fireproof location, and be made available only to authorised persons.

#### ACKNOWLEDGMENTS

The original procedures for handling incoming specimens were written by Robert D. Fisher, who also read and commented on an earlier version of this report, as did J. Phillip Angle and Alfred L. Gardner.

## REFERENCES

- AGRAWAL, O. P. (ed.). 1974. *Documentation in museum*. Museums Association of India, New Delhi.
- BARCAW, G. E. 1975. *Introduction to museum work*. American Association for State Local Museums, Nashville, Tennessee.
- BORGSTEDE, A. 1974. Accessioning procedures in small museums. *Alberta Mus. Rev.*, **1** : 6-7.
- DEBORHEGYI, S. F. 1958. Proposals for a standardized museum accessioning and classification system. *Curator*, **1** : 77-86.
- DUDLEY, D. H. *et al.* 1979. *Museum registration methods* (2nd ed.). American Association of Museums, Washington, D.C.
- GUTHE, C. E. 1970. Documenting collections : Museum registration and records. *Am. Ass. State Local Hist. Tech. Leaflet*, 58.
- REIBEL, D. B. 1978. *Registration methods for the small museum*. American Association for State and Local History, Nashville, Tennessee.
- ROSS, D. 1972. A basic catalogue system. *The Grand New Dawson and Hind Quarterly*, **2** : 26-30.
- SIMPSON, G. G. 1945. The principles of classification and a classification of mammals. *Bull. Am. Mus. nat. Hist.*, **85** : 1-350.
- WILLIAMS, S. L., LAUBACH, R. and GENOWAYS, H.H. 1977. A Guide to the management of recent mammal collections. *Spec. Publ. Carnegie Mus. Nat. Hist.*, : 1-104.

## DISCUSSION

- Q. Does your museum have any special system for accessioning and cataloguing unusual materials such as tissue samples, photographs or slides of karyotypes?
- A. We do not catalogue these materials unless they are accompanied by a voucher specimen. A separate catalogue for these materials could be established, and I would recommend a centralised system rather than relying on individual curators to keep their own records.

- Q. In the museums where protein-taxonomy and chromosome studies are being carried out, what methods are adopted in U.S.A. for accessioning and cataloguing the different variants reported in the same identified species?
- A. The same system is used regardless of the level of identification of the specimen. A specimen can be catalogued as 'Bat' or '*Cynopterus sphinx*' or '*Cynopterus sphinx sphinx*' or '*C. sphinx sphinx*, Cototype B'
- Q. How would you compromise regarding your specimens and making them available for viewing or study by persons whose value of these specimens varies from yours?
- A. Research collections should be made available only to qualified researchers and a firm written museum policy restricting usage of specimens is often helpful.



## ACCESSIONING AND REGISTRATION

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### INTRODUCTION

An institution engaged in the taxonomic studies of animals would surely like to collect more and more of specimens. But such specimens can be of real use in the study of taxonomy only if precise and systematic records regarding the various data with respect to each and every individual specimen thus collected, are maintained. Accessioning and registration are the two processes, which aim at doing this. These two processes come between the collection of the specimens in the field and their final storage for future utilisation.

Neither exactly the same procedure is followed in accessioning and registration of specimens nor even these two processes are known by the same name, in different institutions of the world. However, the purpose of these two processes, as stated above, remains the same in all institutions maintaining large zoological collections for taxonomic studies. The primary object of the present communication is to put on record as to how accessioning and registration of mammalian specimens are followed in the National Zoological Collections of India, housed in the Zoological Survey of India, Calcutta.

### CURRENT METHODS OF PROCUREMENT OF MAMMALIAN SPECIMENS IN THE NATIONAL ZOOLOGICAL COLLECTIONS OF INDIA

For a proper understanding of the procedures followed in accessioning and registration of mammalian specimens in the Zoological Survey of India, a thorough knowledge about the methods of procurement of mammalian specimens (skins and skulls, fluid preserved specimens, skeletal material, etc.) in this institution is an essential prerequisite.

At present, the Zoological Survey of India procures mammalian material by four different methods, viz.—(1) by collecting in the field, (2) by accepting donations of specimen, (3) in exchange of specimens with other museums, and (4) by purchase.



*Collecting in the field*

The Zoological Survey of India procures the large majority of its mammalian specimens through actual collecting in the field, by its workers. Mammalogists of the Survey, though primarily collect specimens of mammal, they also collect other groups of animal, if and when the situation permits. Similarly, workers of the Survey specialising in other groups also try to collect mammals in addition to the animals of their own interest. After reaching the headquarters in Calcutta, the leader of a collecting party sorts out different groups of animal. The mammalian material of the collection is then forwarded to the Officer-in-Charge of the Mammal and Osteology Section, for further processing.

Please receive the following specimens of mammal  
collected during the Namdapha Survey, 1981 :-

60 examples of bat —

Cynopterus - 46 ex. (all wet)

Macroglossus - 4 ex. (3 wet, 1 dry)

Sphaerias - 8 ex. (6 wet, 2 dry)

Magaerops - 2 ex. (1 wet, 1 dry)

---

Total : 60 examples

*S. Biswas 1/9/82*  
( Dr. Shyamrup Biswas )

Zoologist

Coleoptera Section

O/C, Mammal and Osteology Section

Fig. 1. A note from the leader of a collecting party of the Zoological Survey of India, to the Officer-in-Charge of Mammal and Osteology Section, forwarding a lot of mammalian specimens. Original size of the sheet of paper : c. 210 by 330 millimetres.

*Receipt of donations*

Every year, quite some number of specimens of mammal are sent to the Zoological Survey of India, by different institutions engaged in research on various aspects of mammal, for identification. After identification, most of these specimens are usually returned to the sender. If, however, some of these specimens are found to be of interest to the Survey in one way or the other, it is only with the written consent of the sender that such specimens are received in the Survey as a premanent donation. Sometimes institutions and individuals send specimens to the Zoological Survey of India straightway as a donation. The Zoological Gardens at Alipur, Calcutta, is another source of mammalian specimens. Mammal exhibits of the zoo, when dead, are usually sent to the Zoological Survey, which receives them as a donation. It must be made quite clear that all these donations are not only permanent, but are also unconditional, *i.e.*, after such donations the specimens involved become the sole and permanent property of the Zoological Survey of India.

*Exchange*

Besides the methods of obtaining specimens mentioned above, procurement of specimens of taxa either totally unrepresented or poorly represented in the collection, by way of exchange with other museums, is also in practice in the Zoological Survey of India.

*Purchase*

Procurement of mammalian specimens by purchase, is least encouraged in the Zoological Survey of India. Nevertheless, it has actually been done in the past. It is by this method that a portion of the mammal collection (including most of the wet specimens) obtained by the Bombay Natural History Society's Mammal Survey of India, Burma and Ceylon, was procured by the Zoological Survey of India (Das 1984). In future also, the Survey, perhaps, will not hesitate to procure specimens by purchase if a collection be found significant.

## ACCESSIONING

After the leader of a collecting party of the Zoological Survey of India sends the mammalian material collected by him to the Mammal and Osteology Section, the Officer-in-Charge of the section officially receives the same, on behalf of the section. Necessary particulars of this lot of specimens are entered in a bound ledger called the 'Acquisition Register'

Sl. No.	Date of receipt	Source	No. & particulars of specimens	Remarks
92	12 Mar 1982	Dr. A. K. Mukherjee, Superintending Zoologist, Higher Chordata Division.	13 examples of bat :- <u>Cynopterus</u> - 8 ex. <u>Megaderma</u> - 1 ex. <u>Rhinolophus</u> - 2 ex <u>Pipistrellus</u> - 2 ex	Collected from Puruliya district, West Bengal, during Feb 1982.
93	10 Jun 1982	Dr. M. Hafezullah, Officer-in-Charge, Platyhelminthes Section	One foetus of a Cetacean	Collected from Goa
94	15 Jul 1982	Shri S. Chattopadhyay, Officer-in-Charge, Wildlife Section	4 examples of bat	Collected from Jatinga, North Cachar district, Assam
95	1 Sep 1982	Dr. S. Biswas Zoologist, Coleoptera Section.	60 examples of bat :- <u>Cynopterus</u> - 46 ex. (all wet). <u>Macroglossus</u> - 4 ex. (3 wet, 1 dry) <u>Sphaerias</u> - 8 ex. (6 wet, 2 dry). <u>Magaerops</u> - 2 ex. (1 wet, 1 dry)	Collected during Namdapha Survey 1981.
96	3 Oct 1982	Dr. A. K. Mandal, Superintending Zoologist, Lower Invertebrate Division	14 examples of bat :- <u>Pipistrellus</u> - 14 ex	Collected from Sundarbans, 24 - Parganas district, West Bengal
97	6 Dec 1982	Shri S. Bandopadhyay Sr. Research Fellow.	Rats - 2 ex (wet) House Shrew - 1 ex. (wet)	Collected from northern West Bengal

Fig. 2. A completed page of the acquisition register. Original size of the page : c 210 by 330 millimetres.

Each page of the acquisition register is approximately 210 by 330 millimetres in area, and has five vertical columns, viz.—(1) Sl. No., (2) Date of receipt, (3) Source, (4) No. & particulars of specimens, and (5) Remarks.

A lot of mammalian specimens received from the leader of a collecting party is allotted a simple sequential number. This number is entered under the first column. Under the second column, the name and designation of the leader of the collecting party is entered. The area from which the lot of specimens has been collected is usually put under the remarks column. If the specimens have been collected by a well-organised faunistic survey trip or expedition, the name of the survey or expedition is entered under this column.

If a lot of specimens is received as a donation, the name and address of the donor (individual or institution) is entered under the second column, while the words 'Received as donation' are put under the last column. Similarly, when a lot of specimens is obtained by exchange with some institution or by purchase from some institution or individual, the name and address of the other party involved in the exchange or sale of specimens, are entered under the second column. Accordingly, an entry like 'Obtained in exchange' or 'Obtained by purchase,' as the case may be, is made under the last column.

When relevant particulars, as stated above, relating to a lot of specimens are entered in the acquisition register, accessioning of that lot of specimens is completed. This method, as followed in the Zoological Survey of India, is quite a simple one, and is in sharp contrast to the method followed in many of the museums in the United States of America (Williams *et al.* 1977, Wilson 1984). The serial number allotted to a lot of specimens is never called the accession number. This number is in no way helpful in subsequently tracing out any specimen of a particular lot bearing this number.

The Zoological Survey of India stresses upon putting down all relevant information such as locality, date of collection, name of collector and sex, external measurements, brief notes on the habits and habitat of the specimen, etc., on the label of the specimen itself. For this reason, perhaps, the Zoological Survey of India can afford to have a simple method of accessioning.

If, however, anybody is interested to know further details as to what other groups of animal were collected by a collector or at which localities the collector made collections during a particular collecting trip, he is to refer to the collector's official report/field note book of that particular trip, a copy of which is deposited with the Field Survey Division, and a second copy of the same is also deposited with the Library of the Zoological Survey of India, Calcutta.

## REGISTRATION

In the Zoological Survey of India, registration of a mammalian specimen is done only when it is made ready for final storage and, of course, properly identified. Registration involves making relevant entries with respect to every identified specimen of mammal in a bound ledger called the 'Specimen Register'. The entries are invariably made with permanent ink.

Each folio of the specimen register is approximately 420 millimetres in length and 340 millimetres in width, with provisions for making 34 entries. It has 11 vertical columns, viz. (1) Reg. No., (2) Zoological name, (3) Sex, (4) Locality, altitude, etc., (5) Name of collector, (6) Date of collection, (7) Nature of collection, (8) Date of entry, (9) Order and Family, (10) Det. by and (11) Remarks.

In the process of registration, each specimen receives an unique number which is known as the Zoological Survey of India Registration Number (abbreviated as Z.S.I. Reg. No. or simply Reg. No.). This is just a simple sequential number, and accession number and the date of registration do not form parts of the registration number, contrary to the practice of cataloguing of specimens in many museums (Wilson 1984).

Particulars regarding the state of preservation of the specimen and the parts preserved (skin and skull, in alcohol, skull extracted or otherwise, etc.) are entered under the seventh column. The date of entry in the specimen register means the date on which a particular specimen was registered. The name of the specialist identifying the specimen is put under column 10. It is a general practice to enter the collector's number under the remarks column. If any specimen bears catalogue number(s) of one or more of the earlier catalogues\*, the same is also put under

\*The catalogues referred to above are as follows :—

Blyth (1863) catalogued the entire mammalian collection of the Asiatic Society of Bengal, while Dobson (1876) appended a catalogue of the specimens of bat present in the Indian Museum, to his monograph of Asiatic Chiroptera. Subsequently, Anderson (1881) and Sclater (1891) catalogued the entire mammalian collection of the Indian Museum, in two separate parts.

The collection of mammals of the Asiatic Society of Bengal was given to the Indian Museum. The later institution, in its turn, turned over its entire mammalian collection to the Zoological Survey of India, at the time of its formation in the year 1916 (Das 1984). Since the mammalian specimens of the Asiatic Society of Bengal and those of the Indian Museum are now part of the mammal collection of the National Zoological Collections of India, these catalogue numbers are often referred to facilitate tracing out further details regarding a particular specimen from these published catalogues.

ZOOLOGICAL SURVEY OF INDIA				REGISTER OF NAMED COLLECTIONS			
No.	Reg. No.	Scientific name	Locality, altitude, etc.	Name of collector	Date of collection	Number of individuals	Other remarks
17436		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17437		"	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17438		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17439		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17440		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17441		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17442		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17443		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17444		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17445		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17446		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17447		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17448		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17449		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17450		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17451		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17452		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17453		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17454		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17455		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17456		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17457		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17458		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17459		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	
17460		<i>Myotis myotis</i> <i>Myotis myotis</i>	Shimoga, Shimoga, India	W. S. S. S.	12.10.1912	100	

Fig. 3. A completed page of the specimen register. Original size of the page : c 340 by 420 millimetres.

this column. If anything regarding the condition of the specimen is found to be worth mentioning, it is also entered under this column.

To every registered specimen of mammal in the Zoological Survey of India, is tied a duly completed departmental printed label. This label, besides bearing the registration number and the zoological name, also provides data regarding locality, date of collection, collectors number, name of the collector, sex of the specimen, etc. A duplicate of the printed label is also tied to the skull of a dry specimen, and to that of a fluid-preserved specimen, if extracted.

The registration number is clearly written on a suitable place on the dorsal aspect of the skull and also on both ramii of the lower jaw, with permanent ink. Similarly, all suitable parts of an osteological material are numbered with the registration number.

#### POST-REGISTRATION PROCEDURES

After the process of registration is over, the particulars of some of the specimens are also entered in one of the two additional bound ledgers, depending on the nature of the specimen.

##### *Register of type specimens*

The data pertaining to every type specimen are entered in a ledger called the 'Register of Type Specimens'. In size, this register is similar to the specimen register, but has 12 vertical columns, viz.-- (1) Sl. No., (2) Type-category, (3) Sex, (4) Z.S.I. Reg. No., (5) Name of species, (6) Family, (7) Locality data, (8) Name of collector, (9) Date of collection, (10) Catalogue No., (11) State of preservation and (12) Remarks (condition of type, etc.), and has provisions for making 26 entries in a single folio. The serial number is a simple numerical sequence starting with one for the first type specimen entered in this register, and is quite distinct from the registration number (column number 4) which is the same number as that in the specimen register mentioned before. Catalogue number(s) corresponding to one or more of the catalogues mentioned earlier is or are entered under column number 10.

##### *Register for osteological specimens*

If only the skeleton (complete or incomplete) of a specimen is preserved, but not its skin or any other body-parts, the specimen is treated as an osteological one. The data relating to such a registered specimen

No.	Type-category	Sex	Z.S.I. Reg. No.	Name of species	Family	Locality data	Name of collector	Date of collection	Accession Catalogue No.	Condition of specimen	Remarks
52	Syntype	Adol. ♀	15532	<i>Crocidura (Crocidura) rubricosa</i> Anderson, 1892	Soricidae	Sibsagar, Assam, India.	S.E. Peal	1892 I.M. No. 241d	15532	Wet	Skull extracted
53	Holotype	Ad. ♀	15540	<i>Crocidura jenkinsi</i> Chalmers, 1928	Soricidae	Wright Mts, South Andaman Island, India.	A.W. Maudslayi	26 Jul 1922	15540	Dry	Study skin and skull
54	Syntype	Ad. ♀	15533	<i>Sorex fuliginosus</i> Blyth, 1855	Soricidae	Tenasserim Province, Burma	Majors Bendinse	1855 I.M. No. 243a	15533	Wet	Skull extracted, forepaw missing.
55	Syntype	Adol. ♂	15534	<i>Sorex fuliginosus</i> Blyth, 1855	Soricidae	Tenasserim Province, Burma	Majors Bendinse	1855 I.M. No. 243b	15534	Wet	Skull extracted.
56	Holotype	Ad. ♀	15544	<i>Anourosorex assamensis</i> Anderson, 1892	Soricidae	Between Sibsagar and Jaipur, Assam, India.	S.E. Peal	Sep 1871 I.M. No. 228a	15544	Dry	Dissected fore and skull, four dentures of the molar series in situ
57	Holotype	Sub-ad. ♀	10932	<i>Pteropus hypomelanus</i> mayis Allen, 1936	Pteropodidae	Horatara, Addu Atoll, Maldivian Archipelago, Sri Lanka.	Marine Survey	1921	10932	Wet	Skull extracted
58	Syntype	Juv. ♀	15643	<i>Pteropus melanotus</i> Blyth, 1863	Pteropodidae	Nicobar Islands, India.	H. Lewis	1846 A.S.B. No. 32A	15643	Dry	Study skin, skull in situ.
59	Syntype	Ad. ♀	15644	<i>Pteropus melanotus</i> Blyth, 1863	Pteropodidae	Nicobar Islands, India.	H. Lewis	1846 A.S.B. No. 32B	15644	Dry	Study skin and skull
60	Holotype	Ad. ♀	15637	<i>Cynopterus brachysoma</i> Dobson, 1891	Pteropodidae	Andaman Islands, India.	F. Stoliczka	1871 I.M. No. 99a	15637	Wet	Skull extracted.
61	Syntype	Ad. ♀	15638	<i>Cynopterus marginatus</i> var. <i>andamanensis</i> Dobson, 1873	Pteropodidae	Andaman Islands, India.	R.C. Tytler	1864 I.M. No. 97X	15638	Wet	Skull extracted
62	Syntype	Ad. ♂	15639	<i>Cynopterus marginatus</i> var. <i>andamanensis</i> Dobson, 1873	Pteropodidae	Andaman Islands, India.	R.C. Tytler	1864 I.M. No. 97a	15639	Wet	Skull in situ
63	Syntype	Ad. ♂	15640	<i>Cynopterus marginatus</i> var. <i>andamanensis</i> Dobson, 1873	Pteropodidae	Andaman Islands, India.	R.C. Tytler	1864 I.M. No. 97b	15640	Wet	Skull extracted
64	Syntype	Ad. ♀	15641	<i>Cynopterus marginatus</i> var. <i>andamanensis</i> Dobson, 1873	Pteropodidae	Andaman Islands, India.	J. Wood-Mason	1872 I.M. No. 9766	15641	Wet	Skull extracted
65	Syntype	Ad. ♀	15642	<i>Cynopterus marginatus</i> var. <i>andamanensis</i> Dobson, 1873	Pteropodidae	Andaman Islands, India.	H. Hornsby	1872 I.M. No. 97dd	15642	Wet	Skull extracted
66	Holotype	Ad. ♀	15618	<i>Macroglossus spelaeus</i> Dobson, 1871	Pteropodidae	Form Caves, Moulmein, Burma.	W. Theobald	1865 I.M. No. 100a	15618	Wet	Skull extracted
67	Syntype	Ad. ♀	15612	<i>Taphozous theobaldi</i> Dobson, 1872	Emballonuridae	Tenasserim, Burma.	H. Theobald	1865 I.M. No. 1876	15612	Wet	Skull extracted
68	Holotype	Sub-ad. ♂	15607	<i>Taphozous kachhensis</i> Dobson, 1872	Emballonuridae	Kutch, Gujarat, India.	F. Stoliczka	1872 I.M. No. 1899	15607	Wet	Skull extracted
69	Syntype	Ad. ♀	15601	<i>Megaderma horsfieldi</i> Blyth, 1863	Megadermatidae	Tenasserim, Burma.	H. Theobald	Jun 1855 A.S.B. No. 60A	15601	Wet	Skull extracted.
70	Syntype	Ad. ♂	15602	<i>Megaderma horsfieldi</i> Blyth, 1863	Megadermatidae	Tenasserim, Burma.	H. Theobald	Jun 1855 J.M. No. 124d	15602	Wet	Skull extracted
71	Holotype	Ad. unsexed	15647	<i>Rhinolophus brevittarsus</i> Blyth, 1863	Rhinolophidae	Vicinity of Dargiling (c. Dargiling), Dargiling District, West Bengal, India.	H.T. Blanford	1857 I.M. No. 116c	15647	Dry	Study skin, skull in situ.
72	Holotype	Ad. ♀	15567	<i>Rhinolophus garoensis</i> Dobson, 1872	Rhinolophidae	Garo Hills, Meghalaya, India.	H.H. Godwin-Austen	1871 I.M. No. 113a	15567	Wet	Skull extracted.
73	Holotype	Ad. ♀	15568	<i>Rhinolophus macrotis</i> Blyth, 1844	Rhinolophidae	Nipal (= Nepal).	B.H. Hodgson	1842 A.S.B. No. 70A	15568	Wet	Skull extracted (badly damaged).
74	Holotype	Ad. ♂	15561	<i>Rhinolophus andamanensis</i> Dobson, 1872	Rhinolophidae	South Andaman Island, India.	J. Hornsby	1872 I.M. No. 110a	15561	Wet	Skull extracted
75	Syntype	Ad. ♂	15562	<i>Rhinolophus petersii</i> Dobson, 1872	Rhinolophidae	No history	—	—	15562	Wet	Skull in situ
76	Syntype	Ad. ♀	15563	<i>Rhinolophus petersii</i> Dobson, 1872	Rhinolophidae	No history	—	—	15563	Wet	Skull extracted.
77	Holotype	Ad. ♂	10666	<i>Hipposideros latvatus</i> grandis Allen, 1936	Hipposideridae	H'Kamti (B. 800' N. 134' E.), Upper Chindwin River, Burma.	G.C. Shortridge	Jan 1961	10666	Dry	Study skin only (skull not found)

Fig. 4. A completed page of the register for type specimens. Original size of the page : c 335 by 420 millimetres.



are further entered in a separate ledger known as the 'Register for Osteological Specimens' This ledger is similar to the specimen register but has 12 vertical columns, viz.—(1) Serial No., (2) Zoological name, (3) Sex, (4) Locality, altitude, etc., (5) Name of collector, (6) Date of collection, (7) Nature of collection, (8) Date of entry, (9) Order & family, (10) Sectional Reg. No., (11) Det. by and (12) Remarks, and has provisions for making 32 entries in a single folio. As in the register of type specimens, the serial number is a simple numerical sequence starting with one for the first osteological specimen entered in the register, and is quite distinct from the sectional registration number (column number 10) which is the same number as that in the specimen register. Statements like 'Complete skeleton', 'Incomplete (post-cranial) skeleton,' etc., are entered under column number 7. Under the remarks column, as usual, the catalogue number(s) and the collector's number are entered.

After the particulars of concerned registered specimens are entered in one or the other additional register, the data of every specimen are now entered on one or more printed cards.

#### *Specimen index cards*

Particulars of every registered specimen of mammal are entered on a set of cards known as the 'Specimen Index Cards' A specimen index card is approximately 150 millimetres in length and 100 millimetres in height. On the top of the card there are suitable spaces for entering the systematic position and the zoological name of the taxon, as also indications regarding the state of preservation (dry or wet) of

ZOOLOGICAL SURVEY OF INDIA, Calcutta.		Phylum CHORDATA Class MAMMALIA Order LAGOMORPHA Fam. LEPORIDAE		
Genus <i>Lepus</i> Linnaeus, 1758		D., dry; W., wet.		
Species <i>Lepus arabis</i> Ehrenberg, 1833				
Reg. No.	Locality	Date of coll.	Collector/Donor	Remarks
20186	Jhajjarkotli, Jammu & Kashmir	13 Nov 1975	S. Chakraborty	♂, Skin & Skull

Fig. 5. A completed specimen index card. Original size of the card : c 100 by 150 millimetres.

all the specimens entered on a single card, and their actual location in the collection. In a specimen index card, particulars of specimens can be entered under five vertical columns, viz.—(1) Reg. No., (2) Locality,

(3) Date of coll., (4) Collector/Donor and (5) Remarks. Wordings like 'Skin and skull,' 'In spirit, skull extracted,' 'Incomplete skeleton', etc., are entered under the remarks column. As the collection of mammals in the Zoological Survey of India, is arranged according to the sequence followed by Ellerman and Morrison-Scott (1966), so are the specimen index cards. Such cards for osteological specimens are maintained separately.

The specimen index cards not only provide the total number of specimens of a particular taxon present in the Zoological Survey of India, and further details as to their localities, dates of collection, collectors, etc., but also act as guides to the actual location of the specimens in the collection.

### *Type cards*

The data of every type specimen are entered on another set of cards called the 'Type Cards' Each type card is 200 millimetres in length and 125 millimetres in height. Besides spaces for writing the systematic position, the name of the taxon and the reference to the original description, on the top of the card, it has provisions for entering particulars of specimens under seven vertical columns, viz— (1) Reg. No., (2) Type Category, (3) Locality, (4) Collector, (5) Date of Collection, (6) Catalogue No. and (7) Remarks (State of preservation, condition, etc.).

### TYPES IN THE NATIONAL ZOOLOGICAL COLLECTION ZOOLOGICAL SURVEY OF INDIA

Genus Biswamoyopterus Saha 1982      Phylum CHORDATA  
Species Biswamoyopterus biswasi Saha, 1982      Class MAMMALIA  
Reference : Bull. zool. Surv. India, 4 (3): 331-336      Order RODENTIA  
Family SCIURIDAE

Reg No	Type Category	Locality	Collector	Date of Collection	Host and Habitat	Remarks (State of preservation condition etc.)
20705	Holotype	Deban (c. 350m) 26 Km. east of Miao, Namdapha, Tirap district, Arunachal Pradesh, India	Shyamrup Biswas & party	27 Apr 1981		Ad. ♂; Dry; Study skin, skull and baculum

Fig. 6. A completed type card. Original size of the card : c 125 by 200 millimetres.

## DISCUSSION

The process of accessioning, as followed in the Zoological Survey of India, is a simple one, and largely differs from that followed in many museums of the United States of America. This is mainly due to the differences between the methods of procurement of specimens in the Zoological Survey of India and U.S. museums. Specimens of mammals only are accessioned in the Mammal and Osteology Section of the Zoological Survey of India, but corresponding to a particular accession number of many of the American museums, the acquisition may contain non-mammalian material as well (Williams *et al.* 1977). The accession number in the latter museums is quite significant, and may even form part of the catalogue number. This helps in the subsequent tracing out of a specimen in a particular acquisition. The serial number allotted to a particular acquisition in the Zoological Survey of India, is in no way equivalent to the accession number. It never forms part of the registration number of the Zoological Survey of India. It also is of no help in tracing out a specimen in a particular acquisition, subsequently.

The process of registration in the Zoological Survey of India may be regarded as the equivalent of cataloguing in most of the museums of the United States of America. Here again, the two processes differ. The registration number in the Zoological Survey of India is a simple sequential number, and neither the serial number corresponding to an acquisition nor the date of entry form parts of it, as these do so in many other museums of the world, even though the date of registration is entered in the specimen register, but under a separate column.

In spite of all the differences between accessioning and registration in the Zoological Survey of India and accessioning and cataloguing in many American museums, as discussed earlier, practically the same purpose is served by accessioning and registration in the Zoological Survey of India as accessioning and cataloguing do in many of the U.S. museums.

## SUMMARY

Accessioning and registration are two of the important processes, which come between the collection of specimens in the field and their final storage for future utilisation.

After the receipt of a lot of mammalian specimens from the leader of a collecting party of the Zoological Survey of India or from a donor, in exchange, or by purchase, necessary particulars of the specimens are

entered in a bound ledger called the 'Acquisition Register.' This is the simple process of accessioning as followed in the Zoological Survey of India.

Specimens thus acquired are further processed in the laboratories to make them ready for identification, and for final storage. Registration of a mammalian specimen in the Zoological Survey of India is done only after it has been properly identified. Registration involves making relevant entries with respect to every identified specimen in a bound ledger known as the 'Specimen Register,' with permanent ink. By way of registration, every specimen gets a unique simple sequential number called the 'Registration Number' To every registered specimen is now tied a departmental printed label, which, besides other particulars of the specimen, bears the registration number. Particulars of every registered type specimen are also entered in another bound ledger called the 'Register of Type Specimens' Similarly, relevant data of every registered osteological material are entered in yet another bound ledger known as the 'Register for Osteological Specimens' Particulars of every registered specimen are further entered taxon-wise, on a set of cards called the 'Specimen Index Cards', while those of every type specimen are similarly entered on another set of cards known as the 'Type Cards'

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#### REFERENCES

- ANDERSON, J. 1881. Catalogue of Mammalia in the Indian Museum, Calcutta. Pt. 1. Indian Museum, Calcutta.
- BLYTH, E. 1963. Catalogue of the Mammalia in the museum Asiatic Society. Asiatic Society, Calcutta.
- DAS, P. K. 1984. The mammalian collection of the Zoological Survey of India. *Souviner Proc. Wksp Mgmt Mammal Colln Tropical Environ.*, Zoological Survey of India, Calcutta: 3 pp.

- DOBSON, G. E. 1976. Monograph of Asiatic Chiroptera, and catalogue of the species of bats in the collection of the Indian Museum, Calcutta. Indian Museum, Calcutta ; Taylor and Francis, London.
- ELLERMAN, J. R. and MORRISON-SCOTT, T.C.S. 1966. Checklist of palaeartic and Indian mammals. 2nd ed. British Museum (Natural History), London.
- SCLATER, W. L. 1891. Catalogue of Mammalia in the Indian Museum, Calcutta. Pt. 2. Indian Museum, Calcutta.
- WILLIAMS, S. L., LAUBACH, R. and GENOWAYS, H. H. 1977. A guide to the management of Recent mammal collections. *Carnegie Mus. nat. Hist. spec. Publ.*, (4) : 105 pp.
- WILSON, D. E. 1984. Accessioning and cataloguing. *Abstr. Wksp Mgmt zool. Colln : Recent Mammal Colln Tropical Environ.* Zoological Survey of India, Calcutta : 18-20.

## **STORAGE, ORGANISATION, AND UTILISATION OF SPECIMENS IN MAMMAL RESEARCH COLLECTIONS**

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### **INTRODUCTION**

A mammal research collection can be compared to a library in purpose—each is involved in organising and storing extensive series of items. In libraries, these items primarily involve books, whereas in mammal collections, these holdings consist of research specimens. In each case, it is imperative that a system of organisation be implemented so that each item has a designated and predictable position in storage. Such a system will allow any desired item to be easily retrieved and replaced by anyone familiar with the system. The mammal research collection does have some major differences that make organisation and storage unique from that of a library. For instance, a mammal collection usually has specimens that may consist of several parts (such as skin and skeletal material). Also, a mammal collection often includes a diverse assemblage of preservation techniques (such as dried skins and fluid-preserved specimens) and specimen sizes that require various methods of organisation and storage. Furthermore, there are unique considerations that are important for developing a workable system for these materials.

The primary consideration in developing any system of storage and organisation for a mammal research collection is to protect each specimen from loss or deterioration. An awareness of all potential dangers (for example, light, temperature and humidity, reaction with materials, insect pests, mildew, flooding, atmospheric materials, fire, security, and mishandling) is necessary. Many of the potential hazards to research specimens can be eliminated, or at least minimised, by providing a suitable building for housing the collection. The building should “provide adequate protection from fire, water, dust, excessive heat or light and other physical hazards” (Committee on Systematic Collections, 1978). Other hazards include fluctuating temperature and humidity, atmospheric pollutants, and inadequate security.

The amount of planning and implementation of proper climate control mechanisms, air exchange and filtration systems, electrical

services, fire prevention methods, and space utilisation are directly proportional to the quality of care provided to the collection. Ideally, climate control should maintain relative humidities between 45% and 65% (Brommelle, 1968 ; Buck, 1964 ; Johnson and Horgan, 1979 ; Macleod, 1978a) and temperatures between 18° and 22°C (65°—72°F) (Stolow, 1966a), but most importantly, it should prevent rapid fluctuations of either relative humidity or temperature (comments on one effect of rapid temperature changes in a mammal collection are given by Van Gelder, 1965). An air filtration system should be able to eliminate most atmospheric pollutants and dust. Electrical services should include adequate and proper lighting (Lull and Merk, 1982 ; Macleod, 1978b) and enough electrical outlets to accommodate available working areas and equipment. Fire prevention methods should employ ways of eliminating fire without causing a greater threat to the collection by the process used (for example, water may cause greater damage than a localised fire). The methods employed in space utilisation will determine the control of several hazards such as insect pests, ultraviolet light (from natural light sources), and security.

Considerations of secondary importance for developing a system of storage and organisation for a mammal research collection are accessibility and working with the resources available (Dunn, 1970 ; are Johnson and Horgan, 1979 ; Waddell, 1971). Ideally, the collection should include staff office, laboratory and preparation facilities, work areas, library and map facilities, equipment and supply storage, room for a dermestid colony (which should be isolated from the building housing the collection), and adequate space for collection storage.

Although most mammal collections currently use stationary case and shelf units for storing the collection, mobile compactor systems may be worth considering, particularly where adequate space is a problem. These systems provide greater storage capacity by moving rows of storage units together to take advantage of unused aisle space (Fig. 1). These units ride on a platform equipped with metal rails and may be moved singly or interlocked and moved in series. Methods of operation vary from manual to electrical. Manually operated systems allow better movement control and are less likely to be immobilised due to malfunction. Perhaps one of the most favourable aspects of compactor systems is that they may be custom-designed to accommodate almost any storage situation. Therefore, it would be possible to incorporate existing storage units with a compactor system. The size and position of such a system will depend on the characteristics (for example, weight, size, and shape) of the items to be stored, amount of usage, and specific storage requirements. These systems may also be modified to provide extra protection for security or protection from physical hazards, such as atmospheric materials, water, fire light, and insect pests.

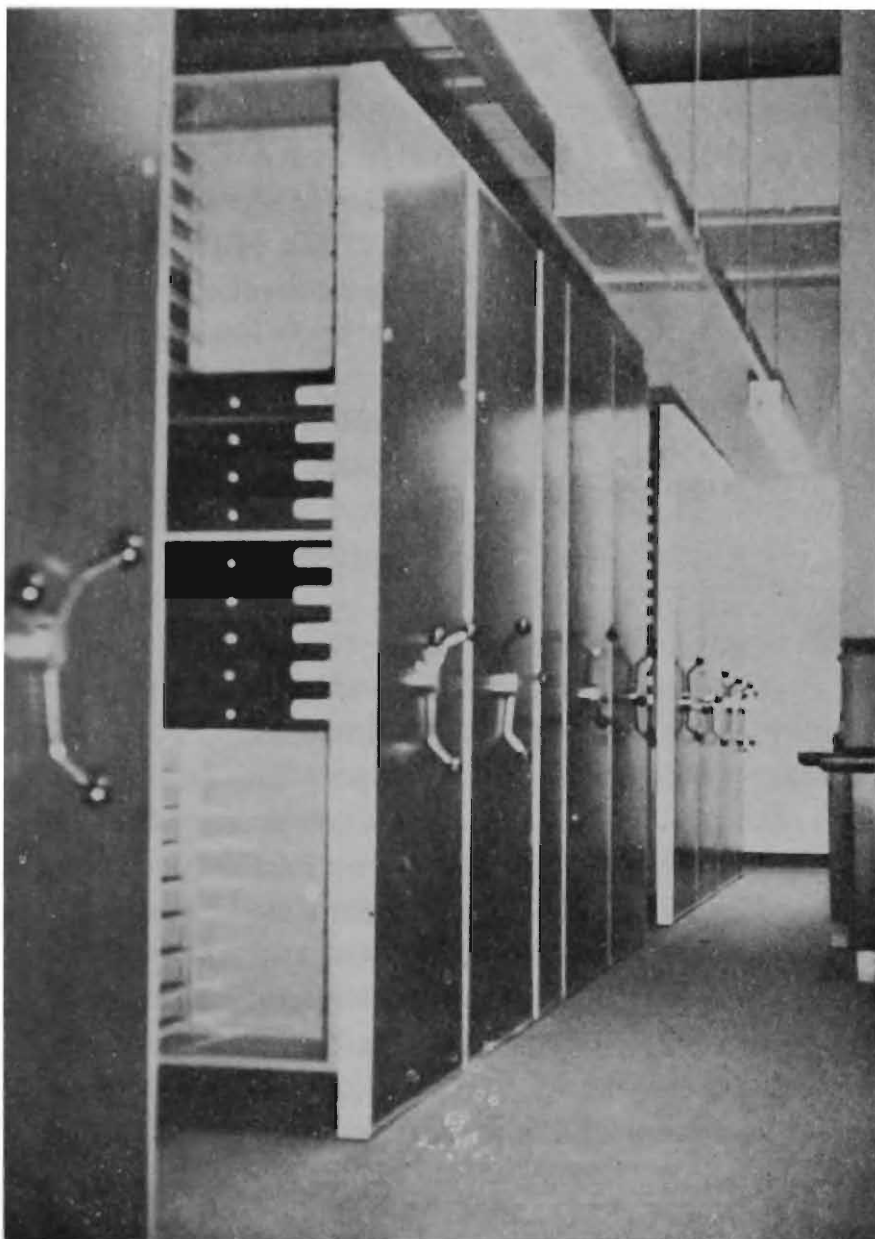


Fig. 1.—Compactor systems provide greater storage capacity by moving rows of storage units together to take advantage of unused aisle space (Section of Invertebrate Zoology Carnegie Museum of Natural History).

Whether the method of storage is mobile or stationary, the area for the collection should include space for temporary storage as well as permanent storage. Temporary storage areas are useful for periodic fumigation, maintaining loans, working with new acquisitions, and holding catalogued materials (generally, in a numerical sequence by collection catalogue number) until all parts are processed and the entire specimen is ready for permanent storage. The methods used for permanent storage and organisation are among the most important factors for the continuous care and future utilisation of the specimens, thus the following will attempt to serve as current treatise of the subject.

The following discusses considerations and methods of typical storage and organisation techniques used for specimens in mammal



research collections in North America. These techniques have been divided into those for skins, skeletal material, fluid-preserved specimens, and other collection items. Further discussion is given to procedures used for the utilisation of specimens in the collection. These subjects have previously been discussed in *A Guide to the Management of Recent Mammal Collections* (Williams *et al.*, 1977). Although additional information has been incorporated, the publication by Williams *et al.* (1977) served as a primary reference for the following text.

## STORAGE AND ORGANISATION

### *Skins*

Physical storage for mammal skins should provide protection specifically from insect pests, mildew, ultraviolet light (from natural light and fluorescent light fixtures), atmospheric materials, humidity and temperature fluctuations, acidic paper, and exposure to abrasion, tearing, or crushing. Extra security measures may be warranted for commercially valuable specimens, such as exotic species or those preserved as tanned skins. The storage system should also allow safe fumigation, easy access for utilisation, efficient use of space, and in most situations, be air-tight (to help control humidity fluctuations ; Stolow, 1966b). Although these criteria are important for all storage situations for mammal skins, the methods of storage and arrangement can vary depending on the nature of the specimen (for example, study skins and tanned skins).

Although standard study skins may be stored in various types of enclosures (Van Gelder, 1965; Williams *et al.*, 1977) most collections use cases initially designed by the U.S. National Museum of Natural History and described by Jackson (1926) and others (Johnson and Horgan, 1979; Knudsen, 1966; Wagstaffe and Fidler, 1968; Williams *et al.*, 1977). These cases are modular for maximum flexibility and use of space. They are referred to as quarter-units (approximate external dimensions are L=72 cm, H=100cm, D=99 cm), half-units (L=145 cm, H=100 cm ; D=99 cm), and full units (L=290 cm, H=100 cm, D=99 cm). The quarter-unit and half-unit cases have been particularly popular for most storage situations. When single-stacked, the case tops can be used for layout space. When double-stacked, the storage space is doubled for the same floor area. They can be arranged in rows, back-to-back, thus creating accessibility to cases on both sides of the aisle. They should be spaced so as to permit easy tray removal and replacement (Fig. 2). Quarter-unit cases can usually hold a maximum of 12 to 15 drawers for specimens; half-unit cases can usually hold 6 to 8 drawers. Ideally, the depth of the drawer will exceed the height of the contents to protect

specimens from mechanical damages caused by other drawers. Each drawer can be subdivided with paper trays for more convenient use of space. These trays provide a clean, splinter-free surface for storage and allow removal of several specimens at a time (Williams *et al.*, 1977). The standard case, with enclosed drawers and a single door, allows easy access to, and fumigation of, the entire case. For specimens maintained in these storage situations it is important that 1) the specimens are not crowded, 2) upper level drawers do not damage specimens in lower level drawers, 3) the door and drawers be adequately labelled to expedite locating specimens and avoiding unnecessary handling of specimens, and 4) the case be air-tight and closed at all times (except when specimens are to be removed or replaced) for protection from physical hazards, specifically light, atmospheric materials, humidity fluctuations, and insect pests.

The sequence of specimens in storage cases is relatively standard with the order going from top to bottom cases (when stacked) and from left to right; inside individual cases the sequence is from top to bottom. The sequence within drawers will vary according to the number and size of specimens and arrangement system adopted for the collection. The primary objective is that the specimens follow a reasonable pattern and are positioned so that the tags can be easily read. If space permits, separate drawers or trays should be used for isolating different taxa or general geographic areas. Generally specimens are placed in drawers from front to back, starting on the left side with specimens lying parallel to the front of the case, or from left to right, starting at the front with specimens lying perpendicular to the front of the case (Fig. 3). If the quantity and size of the specimens justify the use of trays to subdivide the drawer, the arrangement within a tray will also be either from front to back or left to right. The sequence of trays within the drawer will depend on how the individual specimens are oriented. (Containers for skeletal material belonging to skins may be kept in smaller trays, designed for the purpose.) Exceptionally large study skins may require diagonal placement within drawers or trays. When planning the placement of specimens it is useful to incorporate adequate expansion space throughout the storage facilities (Williams *et al.*, 1977).

Prior to organising a collection each specimen should meet certain criteria to promote continuity and ease of handling. For skins these criteria are : 1) all original tags are maintained with the specimen; 2) for study skins, the tags are securely tied to the right ankle of the specimen (if the number of tags is excessive, it may be advisable to restring all of the tags on a single string); 3) the acronym (or name) and catalogue number of the collection are written in permanent black ink on each tag; 4) each specimen is identified to subspecific level, if possible; 5) all scientific names are written on tags with a *pencil* to allow easy and

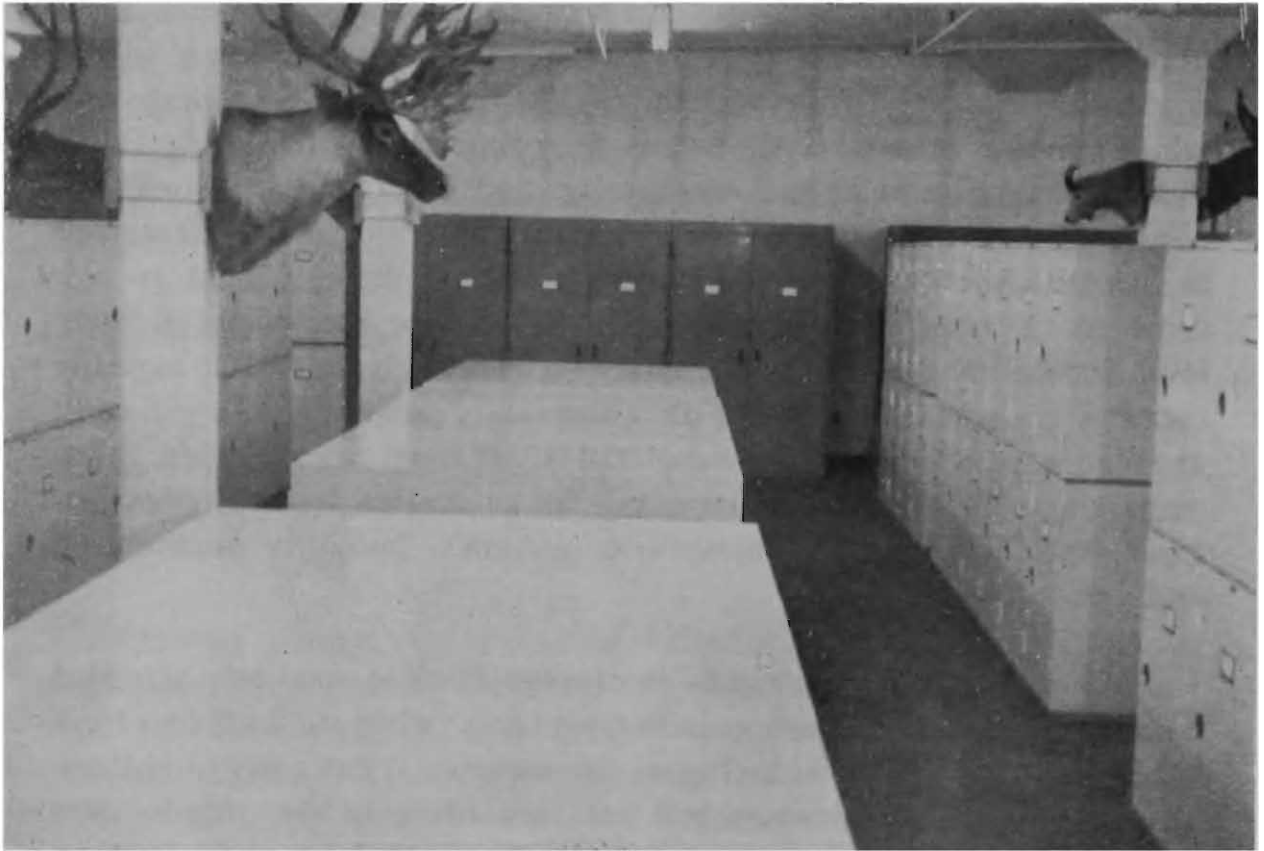


Fig. 2.—The tops of single-stacked cases provide useful layout space, whereas double-stacked cases increase storage space over a given floor area. Cases arranged in rows, back-to-back, with adequate aisle space for easy drawer removal and replacement, provide efficient use of space (Section of Mammals, Carnegie Museum of Natural History).

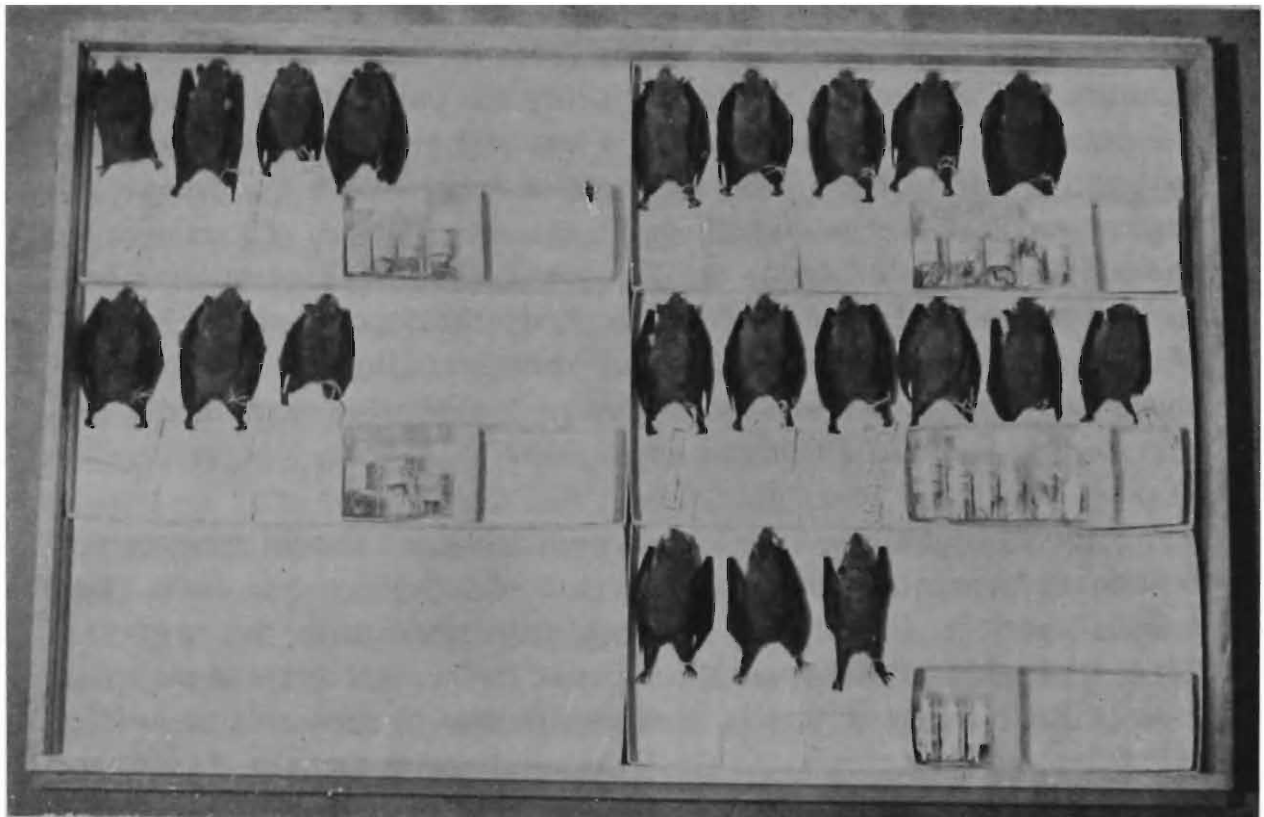


Fig. 3.—Although the precise arrangement of specimens in a drawer will vary according to size, shape, and numbers, the primary objective is to provide adequate space for individual specimens, to position the specimens so that the tags can be easily read, and to allow adequate space for expansion.

neat changes for misidentifications or subsequent taxonomic revisions; 6) the nature of the specimen (for example, skin only) is sometimes recorded on the label. Extreme care should always be taken to insure that all records and labels are legible and correct.

Considerations for the organisation of the collection are size and number of specimens, type of preservation, available facilities, nature of utilisation, and fields of interest of the professional staff. Assuming the size and number of specimens is typical and adequate storage facilities are available, it is probably best to organise the collection in a manner that is logical and familiar to collection workers and users. For most collections a phylogenetic arrangement is the most logical; the advantage of such an arrangement is that related taxa are kept in close proximity to one another. There are several sources that may be followed for arrangements, such as Corbet and Hill (1980), Honacki *et al.* (1982), and Simpson (1945). Generally, this arrangement is followed to the level of subfamily; using a phylogenetic arrangement to the generic level requires more familiarity and accounting for positions of newly described or revised genera. Lower taxonomic levels, such as genus, species, and subspecies are simply arranged alphabetically. An alphabetical arrangement is more functional because of the ease of retrieval and reinstallation for all people that may work in the collection. Specimens of the same taxa are arranged geographically following an alphabetic sequence for the country, subsequent political subdivisions, and reference point (A few North American collections use a method, which originated at the Museum of Vertebrate Zoology at Berkeley. This method involves a geographical arrangement of localities from northwest to southeast, beginning with countries and following with the same arrangement within political subdivisions). At this point it may be desirable to arrange the specimens sequentially by collection catalogue number or incorporate a more complicated system involving further subdivisions such as specific locality designations around a reference point (localities are arranged from north to south; if two or more localities are at the same latitude, the localities are arranged from west to east), preparator (alphabetically), and preparation number (sequentially) (Williams *et al.*, 1977). Whatever arrangement is followed, it is important to have a method that will establish a predictable position for each specimen. When the specimens have been properly and permanently positioned in the collection, the case and enclosed drawers should be appropriately labelled to indicate the contents.

Another type of mammal preparation involves tanned skins. If it is possible, the best storage for such skins is lying flat and separated from other specimens (Hawks *et al.*, 1984). However, many collections have established specialised rooms for the purpose. In these rooms, the skins are tied through the eyes, ears, or nostrils with a cord; the skin and cord

are suspended from hooks and crossbars on metal racks (Fig. 4). Generally, detailed arrangement and organisation are difficult in such storage conditions, but specimen arrangement might be a taxonomic, geographic, size, or a combination system depending on the number of specimens and the dimensions of the storage chamber. Hawks *et al.* (1984) describe the use of special hangers, constructed of PVC plastic pipe and ethafoam sleeves, as an alternative solution that provides better methods of organisation as well as better care for the specimens (Fig. 5).

### *Skeletal Material*

The storage of skeletal material should provide protection from dessication, atmospheric materials, temperature and humidity fluctuations, and exposure to mechanical damage. In situations involving ivory, additional security measures may be warranted. The methods of storing skeletal material will primarily depend on size, whereas the method of organisation will also include the nature of specimen preservation.

Skeletal material of small specimens is usually stored in standard specimen cases (see *Skins*). Within the specimen case, skeletal material of each specimen should be placed in a container of appropriate size—not so small to risk damage and not so large as to waste space. Generally, such containers involve selected sizes of vials or paper-constructed boxes (Fig. 6). Vials may be either plastic (Palmer, 1946) or glass. Although the former is less expensive, there is a greater risk of it reacting to heat and some chemicals (Van Gelder, 1965). Vials composed of a quality glass are less reactive, but more susceptible to breakage. The stoppers for the vials are usually constructed of plastic, metal, or cork. They should be air-tight, easily removed, and nonreactive. Polyethylene plastic caps meet these criteria. Cork stoppers will become brittle with age. Stoppers with a diameter that exceeds the diameter of the vial will cause the vials to lie unevenly. Skeletal material that is too large for vials must be placed in boxes. Ideally, these boxes are available in various sizes to allow the most efficient use of space in the drawers. The lids should fit snugly enough to remain on the box in the event the box is turned over. It may be convenient to use smaller containers inside the primary storage container to store small skeletal elements of the specimen. To assist in maintaining the organisation of vials and small boxes, heavy paper trays are used. If a tray is not completely filled, it is possible to prevent the specimens from moving around by snugly fitting a block of ethafoam next to the containers. Further protection for the skeletal material can be provided by adding tissue paper to the inside of the storage container. Cotton is not recommended for this purpose because of its tendency to snag on specimen parts.



Fig. 4—Tanned skins are often stored in fur rooms by hanging them from metal racks with the use of hooks and cords (Department of Zoology, University of Montana).

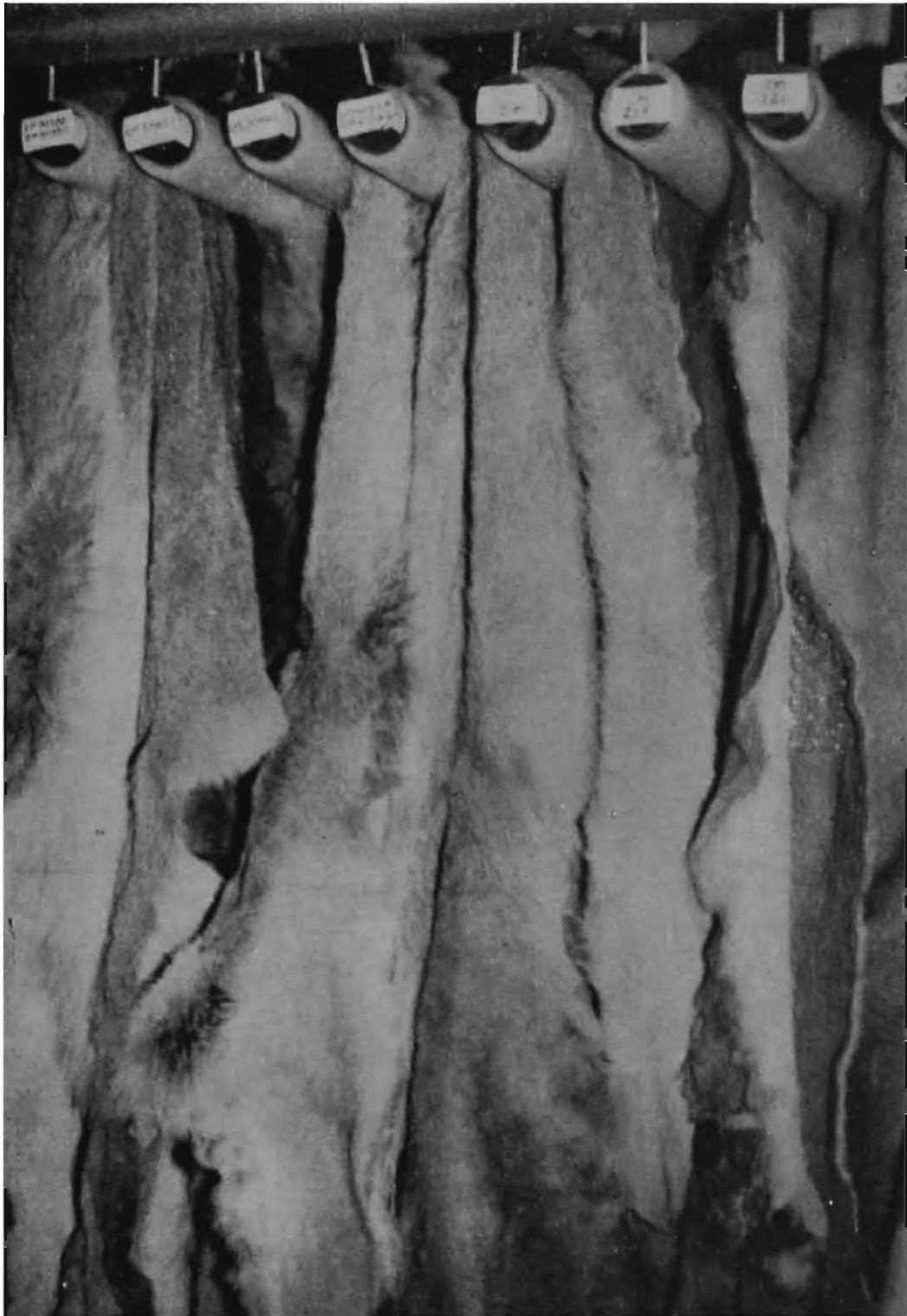


Fig. 5—Tanned skins may be given better support and organisation with the use of special hangers described by Hawks et al. (Section of Mammals, Carnegie Museum of Natural History).

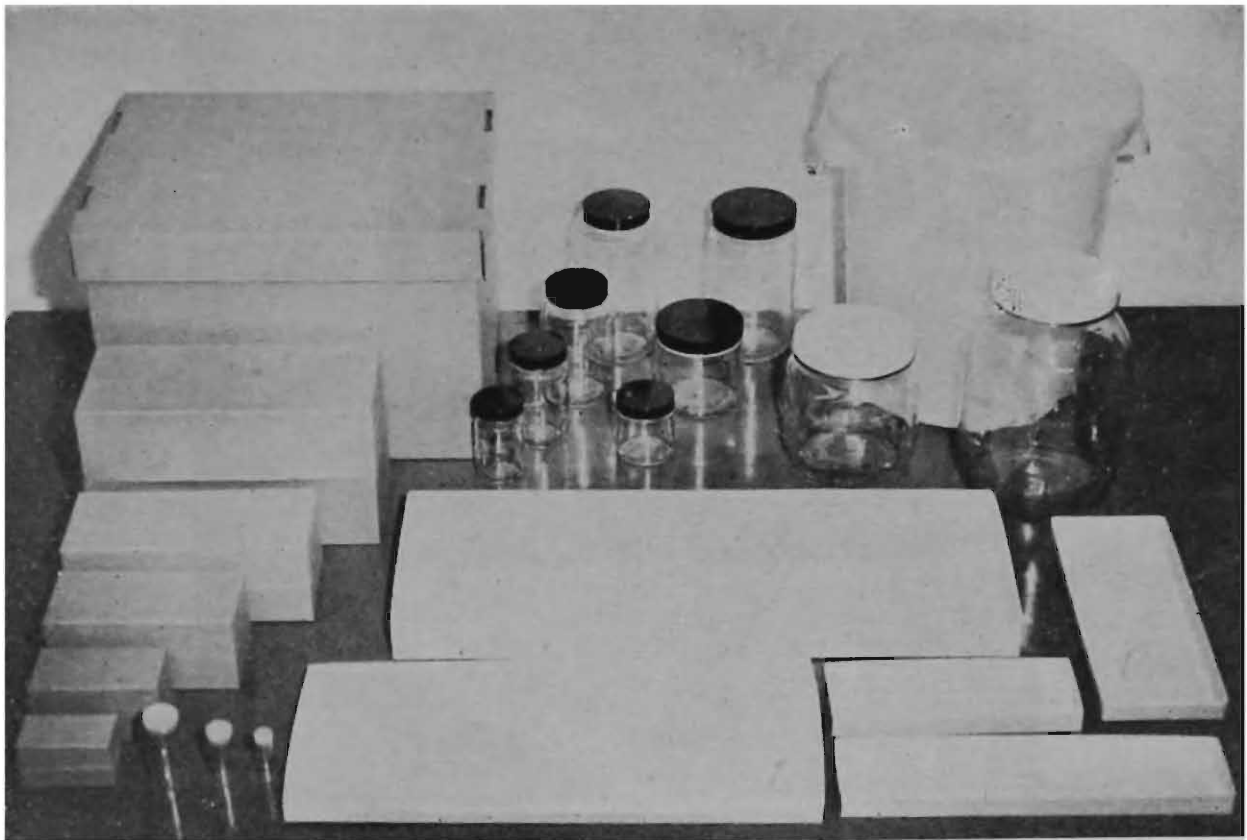


Fig. 6—Curatorial supplies used for the storage of mammal specimens. Large flat trays may be used for subdividing a drawer for study skins. Assorted vials, boxes, and trays are suitable for skeletal material. Various sizes of glass or polyethylene containers may be used for fluid-preserved material.



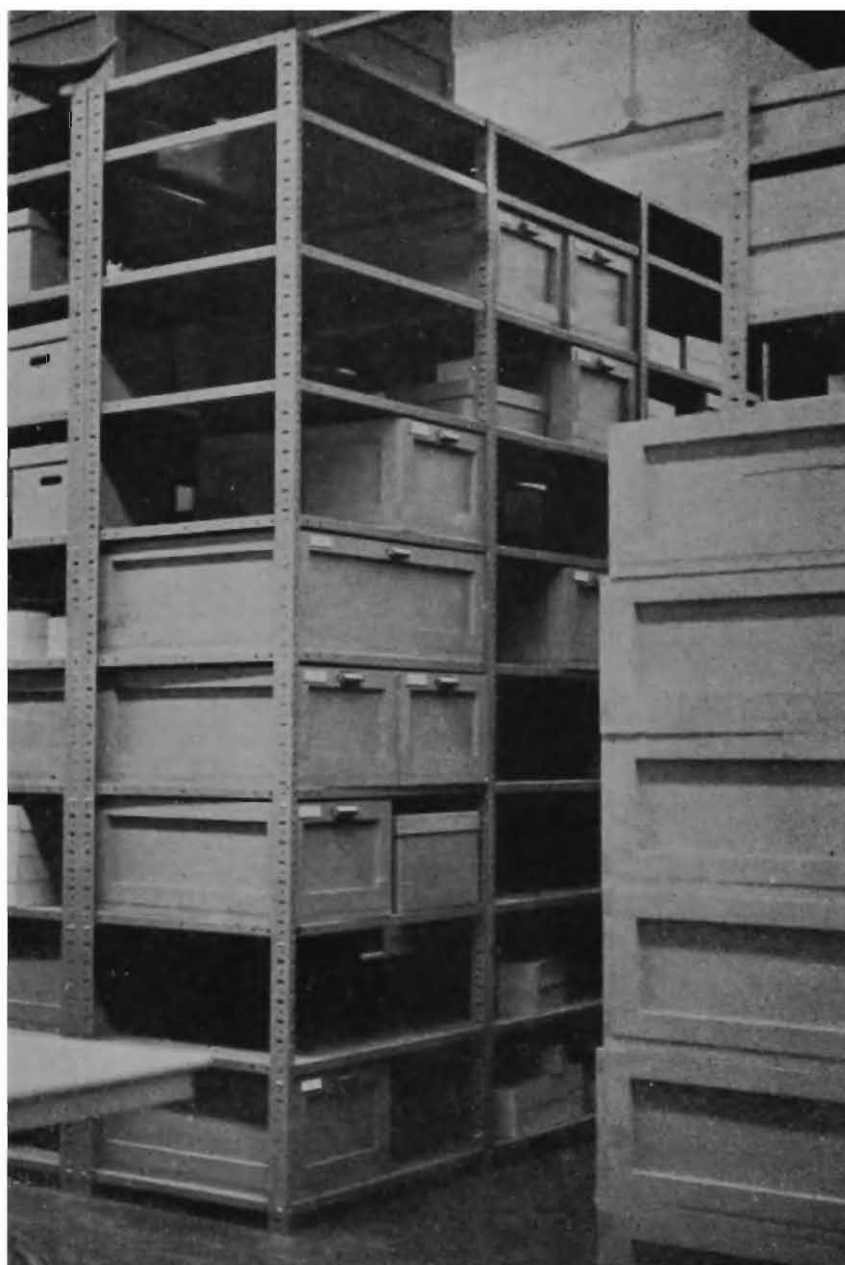


Fig. 7.—Heavy-duty shelving provides an effective method of storing and organising large skeletal material (Section of Mammals, Carnegie Museum of Natural History).

Generally skeletal materials of large specimens are stored in appropriate sized cardboard or wooden boxes with covers (Van Gelder, 1965). Lewis and Redfield (1970) recommend using fiberglass tote boxes which have the added benefit of stacking inside each other when not in use. An attempt to maintain an air-tight storage situation should be made. This may be promoted with the use of plastic bags (preferably of a heavy-duty polyethylene construction) to contain the skeletal material within the box. Colbert (1961) describes the construction of inexpensive, heavy-duty shelving suitable for massive skeletal material (Fig. 7).

Cranial material presents a variety of unique storage problems. Many skulls may be stored with the postcranial skeletons. However, if

space-consuming antlers or horns are present, alternative storage techniques are required. For such situations the skull is usually stored separately from postcranial skeletal material (if present). Antlered or horned skulls (Fig. 8) may be stored on parallel bars (Jackson, 1926), shelving, or heavy-duty screening (with the use of hooks that are bolted to the basioccipital of the skull (Williams *et al.*, 1977). For any open storage situation, it is recommended that plastic sheeting be carefully draped over the specimens to provide protection from atmospheric materials, particularly if the material is seldom used. Large skeletal material or mounted skeletons can be particularly space-consuming. For such specimens, exhibition may be the best solution.

Before skeletal material is placed in permanent storage, the data and identification of each specimen should be verified. Also, it is equally important that all nonosseous tissues and materials be removed from the bones, and all bones (if large enough) and tags be legibly labelled with the collection acronym and catalogue number (using permanent black ink). Because skeletal material is generally prepared with minimal data associated with the specimen tags (preparator's initials, preparation number, and sex of specimen), it is necessary to provide an additional label so that the material can be efficiently placed in its proper position in the collection. These labels may include collection acronym (or name), collection catalogue number, taxon, sex, nature of preparation, collecting locality, collecting date, preparator, and preparation number (Fig. 9). If the skeletal material represents the entire specimen, it is useful to include external measurements and reproductive data. These labels are placed inside vials or attached to the outside of boxes.

Usually the organisation of skeletal material will follow that used for skins (see *Skins*). However, the nature of specimen preservation will often determine how the skeletal material is handled. For specimens preserved as skin and skeletal material, both parts are kept together so that the entire specimen is available at one location. Specimens that consist of only skeletal material, or a skull removed from a fluid-preserved body, can be stored with other specimens, but such handling will probably result in inefficient use of space. Better space utilisation and ease of handling can be provided by storing such specimens at the end of the taxa (genus, species, or subspecies, depending on numbers of specimens involved). Further ease in handling can be provided by colour-coding labels (with coloured pencil) according to the nature of preservation of the specimen (for example, blue for skeletal material only and yellow for skeletal material removed from fluid-preserved specimens). For every storage situation employed for skeletal material, it is important that containers, drawers, cases, shelving, or other storage facilities be adequately labelled to provide overall organisation and easier utilisation.

*Fluid-preserved Material*

Storage for fluid-preserved material should provide protection from light, dessication (Van Gelder, 1965), abnormal alcohol concentrations, heat, mechanical damage, and materials that react with the preservative. The storage situation should also allow easy access for utilisation and easy inspection of fluids.

Storage facilities for alcohol-preserved specimens are usually isolated from other parts of the collection. Ideally, these specimens would be maintained in their own room which would have adequate ventilation, fire prevention mechanisms, and no windows. Typically, fluid-preserved specimens are kept on metal or wooden shelving to allow easy access. Individual shelves should be equipped with holders for labels and safety guards along the front edge. Aisle space between shelving units should be wide enough to allow easy handling of stepladders and carts (Fig. 10).

Fluid-preserved specimens may be stored in a variety of containers (Fig. 6) depending on the size and number of specimens. Wide-mouthed glass jars are popular for storage of such materials. A modest selection of jar sizes will accommodate most storage situations. The lids for jars should provide an air-tight seal and be nonreactive with the preservative. One of the better glass jars to use is equipped with a rubber gasket and glass lid that is secured with a wire bail. Jars that use a bakelite lid with a vinyl-coated, paper liner are also popular. Metal lids are sometimes used, but polyethylene liners should be used with them to minimize any reaction between the metal and preservative. Cork and neoprene-rubber stoppers should not be used to seal containers because reactions with the preservative will cause a decrease of the pH level and a darkening of the solution (Levi, 1966). In situations where the number or size of specimens exceeds the capacity of the largest jar, it is possible to use stainless steel tanks, plastic carboys, or earthenware crocks. Dundee (1962) describes the manufacture of storage tanks using plywood lined with polyester resins. For large tanks, storage at floor level and the use of casters or dollies is recommended.

Fluid-preserved specimens are usually fixed in a 10% formalin solution. After the tissues have been fixed, the specimens are soaked in running water to remove the formalin and then transferred to a permanent preservative of 70% ethyl alcohol or 50% isopropyl alcohol (Hildebrand, 1968). It is important that specimens should not be crowded in storage containers. Zweifel (1966) suggests that the volume of the preservative should be twice the volume of the specimens. It is particularly important that specimens remain submerged to avoid dessication. It may be useful to fill all containers to a specified level so that leaking containers and evaporation can readily be detected.

Prior to placing fluid-preserved specimens in permanent storage, the identification and data for each specimen should be verified. Each specimen is labelled with at least a high-quality tag with the preparator's initials, preparation number, and sex of the specimen. The collection catalogue number is recorded on the reverse side of the tag or on a separate tag. The ink used for labelling tags should be resistant to alcohol. Tags are tied around the right ankle (or knee in bats). Because tags on fluid-preserved specimens usually contain minimal data associated with the specimen and such tags are difficult to read when specimens are stored in fluid, it is necessary to provide a high-quality paper label to identify the contents of a container. This label should include at least the taxon, collection catalogue numbers, and collecting localities (Fig. 11). This label should be placed with the container where it can be easily read.

The organisation of fluid-preserved specimens will depend on the storage facilities, number of specimens, size of specimens, and type of preservations. Some collections may elect to maintain different alcoholic collections for different fluid preparations, such as whole specimens, embryos, organs, and other parts. Assuming adequate space is available, a systematic arrangement, similar to that discussed for study skins (see *Skins*), is useful. Geographical arrangements following the systematic arrangement are functional, in most cases, at the level of country and the next political subdivision. Below these geographical levels, it may be necessary to combine specimen samples from different localities in the same containers to preserve storage space. If storage facilities are limited, it may be better to store similar sized containers together without regard to taxon. This method is used at the U.S. National Museum. Such organisation will probably not follow a desirable systematic or geographic arrangement. Therefore, it is necessary to identify storage locations and maintain a phylogenetically-arranged record file for locating specimens. Advantages of this system include better utilisation of space and the elimination of reshuffling as new material is incorporated. However, retrieval and replacement of specimens and maintaining a specimen card file may be time-consuming.

### *Other Collection Items*

*Type specimens* are the most valuable holdings of any mammal research collection, thus the care of these specimens should never be compromised. Considerations for the care of specimens has been discussed in previous sections. However, type specimens are usually afforded additional care by being placed in their own special storage units that are appropriately labelled and separate from the main collection. This measure provides additional security by restricting access and eliminating such specimens from normal handling activities (for example,



Fig. 8.—Antlered or horned skulls may be stored on parallel bars (left), shelving (middle), or heavy-duty screening (right) (left, middle—Department of Zoology, University of Montana; right—Section of Mammals, Carnegie Museum of Natural History).

CARNEGIE MUSEUM OF NATURAL HISTORY  
SECTION OF MAMMALS  
65091

OCHOTONA PRINCEPS LEMHI  
IDAHO: BLAINE CO; 3 MI S, 12 MI W  
KETCHUM

GROEN, J A 719

M/SB 06 JUN 1979

Fig. 9.—An additional tag is placed with skeletal material to provide basic data for the material and to facilitate handling and organisation. This tag was computer-generated.



Fig. 10.—Fluid-preserved specimens can be easily stored and organised on shelving. Ideally the shelf-units will be equipped with label holders and safety guards along the front edge. Aisle space between shelving units should be wide enough to allow easy handling of stepladders and carts (Section of Mammals, Carnegie Museum of Natural History).

CARNEGIE MUSEUM OF NATURAL HISTORY SECTION OF MAMMALS	
Peromyscus leucopus novaboracensis	
SPECIES	
CAT. NO.	LOCALITY
70053	Rhode Island: Tiverton Co.; 1 mi N, 1½ mi E Tiverton
70057-62	" " "

Fig. 11.—A high-quality paper label is often used to list the fluid-preserved specimens stored in a container. The dimensions of this label are 127 mm by 63 mm. A larger label (140 mm by 95 mm) is also used for more extensive listings.

loans and collection shifting) of the collection. Each type specimen is individually stored in an appropriate container to facilitate limited handling and to provide better protection from mechanical damage. Each specimen is also conspicuously labelled as a type specimen to insure it will receive the proper handling and care. This labelling has traditionally been indicated with red labels or red lettering. The labelling of each type specimen should include a notation of the author, reference, and year of publication of the type description. Type specimens are normally arranged phylogenetically.

Occasionally, a mammal research collection will possess whole *body mounts* and *trophy heads* that have been removed from display and require special storage. Many times these items are catalogued and may be of considerable scientific value. These items should be protected from the same physical hazards as those of study skins (see *Skins*). Often data for such items are inadvertently lost, particularly during periods when they may be exhibited. Therefore, it is important that each item be fully and permanently labelled in an appropriate location, such as the bottom or back side of the base plate. If the body or head mounts cannot fit into protective storage units, it may be best to cover the specimen with a cloth or plastic sheeting. The specimen should be periodically checked for insect infestations and possible signs of deterioration (Van Gelder, 1965). Often the number of such specimens maintained by a collection is not large enough to warrant a special arrangement; instead,

it may be best to arrange these items in a manner that will provide the most protection from mechanical damage.

*Speciality collections* may include a wide variety of items that have their own storage and organisation requirements. These collections may include osteological materials (for example, bacula, hyoid apparatus, and ear ossicles), microscope slide preparations (for example, hair samples, tissue sections, blood smears, sperm samples, karyotypes, and parasites), and other mammal-related materials (for example, casts, scats, pellets, cheek and stomach contents, and nests). Osteological materials are often stored with corresponding skeletal material of the specimen, but some collections prefer to maintain separate storage facilities for these items. Depending on the nature of osteological material or other related materials, boxes, vials (Van Gelder, 1965), insect pins (Friley, 1947), or microscope slides (White, 1951) can be used for storing individual items. Microscope slides may be stored flat or vertically in slide boxes or specially-designed cabinets. Organisation within a specialty collection will often be phylogenetic to family or subfamily, alphabetic to species, and then sequentially by collection catalogue number. If the quantity of items in a collection is excessive, a more refined arrangement may be desirable. These arrangement systems may also be replaced with a different, but more functional, system designed for the collection. As with other parts of the research collection, it is very important to provide adequate labelling of specimens and storage areas to maintain the scientific integrity and facilitate handling of the material.

Many research collections maintain special *teaching collections* for instructing public visitors and students. Such collections serve many purposes besides education; they eliminate the need to use scientifically valuable specimens from the research collections and they provide a use for specimens that have no scientific value. Although teaching collections must be considered expendable in nature, any care whatsoever given to the specimens will increase availability for continued use, thus reducing the need for replacement. It is important that all materials in a teaching collection be separated from the main collection at all times. Usually a general phylogenetic arrangement is suitable for teaching collections.

Specimens without proper data are virtually worthless to a research collection, thus *written records* are just as much a part of a specimen as the specimen itself. Written records in the form of field notes, field catalogues, specimen data sheets, collection catalogues, accession records, permits, and pertinent correspondence increase the value of specimens. These documents should be protected from excessive moisture, insects, ultraviolet light, acidic paper, heat, atmospheric materials, and mishandling. The methods used at any institution will usually be determined by their respective needs and resources.



## UTILISATION

The utilisation of specimens in a research collection can lead to new problems unless certain precautions are followed. For normal internal usage it is a simple matter of temporarily removing material for examination and returning it to its proper place when finished. During such examinations one should not neglect other specimens by inadvertently leaving doors to cases or lids to jars open—each serves a purpose of protection and should therefore be used continuously. If specimens are to be removed for extended periods of time a note explaining its absence is recommended—such notes are referred to as “removal slips” (Fig. 12). This note should include the catalogue number, name of species, items removed, and person or place where the material can be found. Not only will such slips inform other users of the status of the material, it will also expedite proper placement of the material when it is returned.

The loan of specimens is another major part of collection utilisation. This aspect of collection management is one of the most important endeavors that a research collection can become involved with. Not only does a collection take on the important responsibility of properly handling borrowed materials, but it also demonstrates to other institutions the professional standards that are maintained for care of specimens. Therefore, a set of criteria have been established for the processing of loans between institutions.

There are a few basic rules that are observed among mammal research collections. These rules are : (1) loans are made between institutions and not individuals because of the legal obligations involved with loans; (2) holotypes are never loaned (Committee on Systematic Collections, 1978); (3) the entire holdings of a taxa of any particular collection are not loaned in a single transaction; (4) not more than 50 specimens are sent on a loan at one time; (5) loans are made for a period of six months with provisions for renewal, if necessary; (6) specimens on loan should be isolated from the rest of the collection and given special care; (7) borrowed specimens are never altered (for example, removing skulls from alcoholics) without prior arrangements from the loaning-institution; (8) loans are always returned in containers in which they were sent and packed in a manner to best protect the specimens. Beyond these basic rules, the procedures have become standard procedures.

The typical loan transaction (Fig. 13) begins with a formal written request. The request should include information about the reason for request, nature and number of specimens desired, length of time required for the loan, and any other relevant information. If possible, a loan can be greatly simplified if specific parts (for example, only the skeletal material) of the specimens are borrowed instead of the entire specimen.

Following the loan request the material in the collection should be examined for fulfilling the loan request and determining the procedure necessary, based on the criteria listed above. If material is removed to be sent on loan, a removal slip (Fig. 12) should be put in place of the specimens removed. All specimens and their parts should be inspected to insure everything is properly labelled and in a condition ready to be loaned. All damages, missing parts, and general conditions should be noted.

After the material to be loaned has been assembled, four copies of a loan form (Fig. 14) should be made. The information on the loan form should include the lender's and borrower's names and addresses, shipping date, value for insurance purposes, and a detailed description of the nature and condition of each specimen in the loan. It may also be advisable to include information about preservatives, shipping container, and data explanation. One copy of the loan form is retained in the files of the lending-institution. The lending-institution sends a letter of notification concerning approval, disapproval, or conditions of the loan. If approval is granted, the original and one copy of the loan form accompany the letter. These copies are verified with the loan upon arrival. Any discrepancies are noted. One copy is retained in the permanent files of the borrowing-institution ; the original is returned to the lending-institution to notify of the arrival and condition of the shipment. The fourth copy of the loan form should accompany the shipment so that the material, sender, and receiver are identified and associated with the specimens. It is often convenient to colour-code the various copies of the loan forms with regard to their specific purposes. It is also convenient to maintain a ledger of all incoming or outgoing loan transactions. Such a practice will provide better control of all loans.

The proper packing of loans is very important because adequate protection must be provided to the material during that period of time that it is out of control of either the lending or borrowing-institution. For this reason shipments are typically sent in crush-resistant boxes constructed of wood. Each specimen is individually wrapped with lightweight, white paper to prevent breaking and loss of parts. Skeletal material should be lightly cushioned with soft tissue paper (cotton is not recommended because of its fibrous nature). Breakable skeletal containers, such as vials, should be individually wrapped so that the contents will be maintained in case of breakage. Hoffmeister (1973) suggests an alternative measure of inserting vials in holes cut into panels of styrofoam or blown polystyrene material. The contents of a loan should not be crowded, and should be well-protected with sufficient amounts of packing material. All packing material should be non-abrasive, non-staining, non-linting, non-absorbent, and light-weight (Fall, 1965). It is best not to send alcoholic specimens with dry specimens. Fluid-

The following specimen(s) is (are) on temporary loan to R.C. Dowler;  
Fordham Univ.; Bronx, New York (X-1984-00) Date 21 Jan 1984  
 (Name and Institution)

Catalog No. CM 70048, 70049, 70050, 70051, 70052, 70054, 70055,  
70056.

Species Peromyscus leucopus noveboracensis

Parts Removed Skin and skull Signature J. Williams

Fig. 12.—Specimens removed from storage for extended periods of time are replaced with a “removal slip” to explain its absence and to facilitate easier replacement after use. The dimensions of this tag are 82 mm by 25 mm. The tag is also coloured light blue for easy recognition.

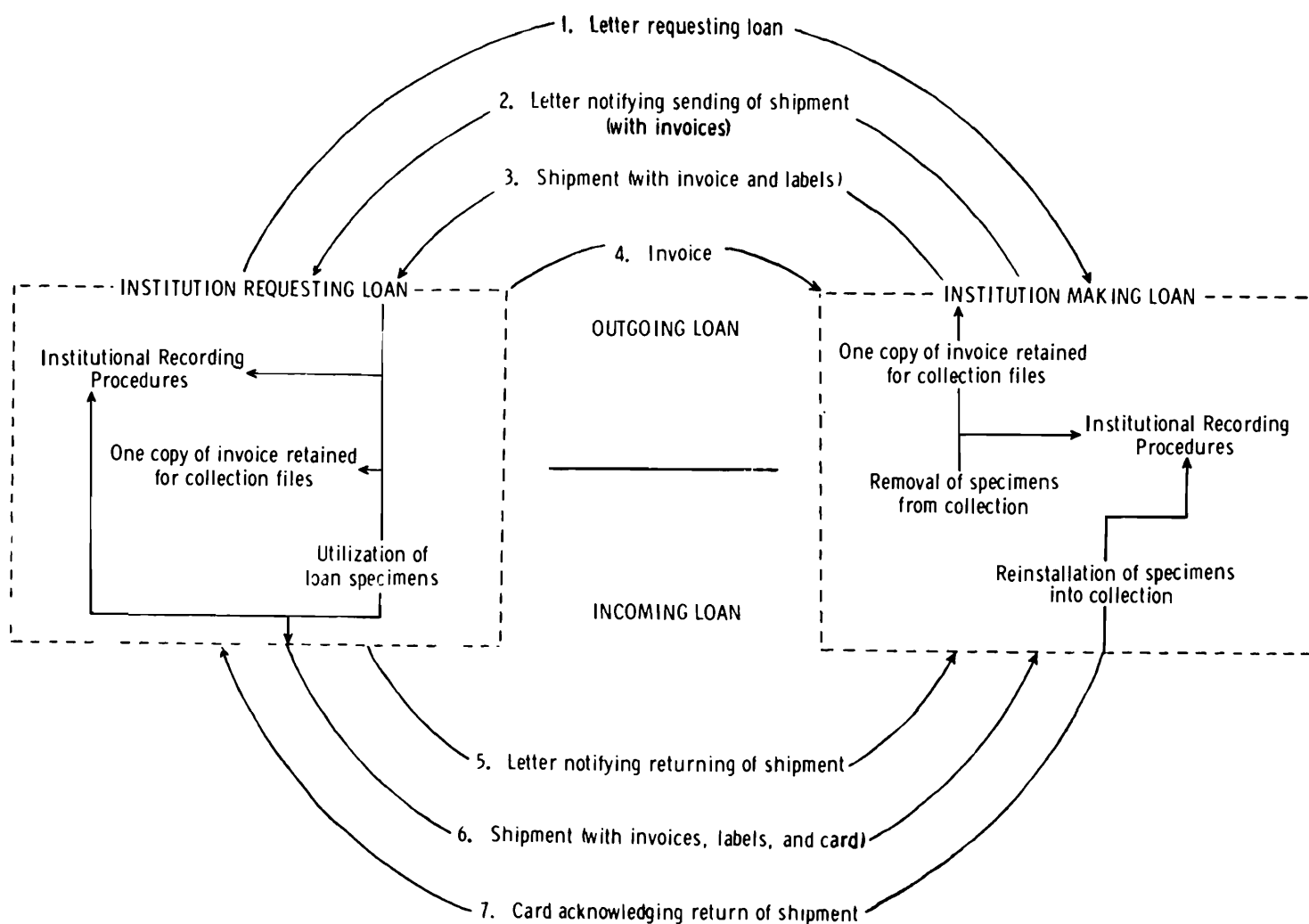


Fig. 13.—Flow-chart illustrating the sequence of a loan transaction.

CARNEGIE MUSEUM      PITTSBURGH, PA. 15213

## INVOICE OF SPECIMENS

TO Department of Biological Sciences  
Fordham University  
Bronx, New York 10458  
Attention: Dr. R. C. Dowler

DATE 21 January 1984SECTION OF MammalsBY S. L. WilliamsVALUE \$400.00METHOD OF SHIPMENT Postal serviceThe following specimens have been forwarded to you this day as a temporary loan

THIS COPY TO BE SIGNED AND RETURNED AT ONCE

## DESCRIPTION OF OBJECTS

15 specimens of Peromyscus leucopus noveboracensis from the state of Rhode Island.

CM70048	skin and skull; good condition
CM70049	" ; basioccipital missing
CM70050	" ; good condition
CM70051	" ; " "
CM70052	" ; " "
CM70053	fluid-preserved (70% ethyl alcohol); skull removed
CM70054	skin and skull; good condition
CM70055	" ; left zygomatic arch broken; auditory bullae loose
CM70056	" ; good condition
CM70057	fluid-preserved (70% ethyl alcohol); skull removed; both zygomatic arches broken; interparietal missing
CM70058	" (70% ethyl alcohol); skull removed; both zygomatic arches broken; interparietal region, basisphenoid region, and rostrum damaged
CM70059	" (70% ethyl alcohol)
CM70060	" "
CM70061	" "
CM70062	" "

Fluid-preserved material was collected from Rhode Island: Tiverton Co , 1 mi N, 1½ mi E Tiverton.

Permission has been granted to remove and clean skulls from CM70059, CM70060, CM70061, and CM70062

Loan is being shipped in two wooden boxes. One box will contain the skins and skeletal material The other box will contain the fluid-preserved specimens

Received \_\_\_\_\_, 19\_\_\_\_

Condition Good except as indicated

above


Please advise of taxonomic changes or suggestions.

Loan made for a period of 6 months unless renewed.

Fig. 14.—Form used for external loans at Carnegie Museum of Natural History. Four copies of the loan are used during a loan transaction. The original is retained by the lending-institution. Two copies are sent to the borrowing-institution who retains one copy and returns the other copy to the lending-institution when the loan is received. The fourth copy accompanies the actual loan during transit.

USFWS Form 3-177  
(revised Sept. 1978)  
Form Approved O.M.B. No. 42 R1476

**U.S. FISH AND WILDLIFE SERVICE**



**DECLARATION FOR IMPORTATION  
OR EXPORTATION OF  
FISH OR WILDLIFE**

**Name of Carrier** \_\_\_\_\_

**Airway Bill or Bill of Lading No.:** \_\_\_\_\_

**Imported or Exported via:**  
☐ air cargo   ☐ ocean cargo   ☐ truck  
☐ rail   ☐ mail   ☐ personal baggage  
☐ automobile license no. \_\_\_\_\_  
state \_\_\_\_\_

**Location where wildlife is available for inspection:** \_\_\_\_\_

**Package or Bale Marks and Nos.** \_\_\_\_\_

**Indicate One:**  
☐ import   ☐ export

**Port of** \_\_\_\_\_

**Date** \_\_\_\_\_

**For Imports Only**  
**Customs Identification No.** \_\_\_\_\_

**Foreign Consignor or Consignee** \_\_\_\_\_  
(name) \_\_\_\_\_  
(address, street, city, state, zip code) \_\_\_\_\_

**Customs Broker or Agent** \_\_\_\_\_  
(name) \_\_\_\_\_  
(address, street, city, country) \_\_\_\_\_

**Shipping Agent or Freight Forwarder** \_\_\_\_\_

**Furnish All Information Below (Invoices or lists providing required information may be attached)**

QUANTITY	SCIENTIFIC NAME Genus      Species	COMMON NAME	DESCRIPTION If live, so state. If product, describe.	DECLARED VALUE	COUNTRY OF ORIGIN

**U.S. License and/or Permit Nos.:** \_\_\_\_\_

**Foreign License and/or Permit:** \_\_\_\_\_  
Country \_\_\_\_\_ No. \_\_\_\_\_

**I certify the information contained herein is true and complete to the best of my knowledge and belief.**

\_\_\_\_\_  
signature      date

**FOR OFFICIAL USE ONLY**

**Action Taken:** \_\_\_\_\_ **Date:** \_\_\_\_\_

☐ cleared  
☐ clearance refused  
☐ seized

\_\_\_\_\_ % of Wildlife Inspected:

**Officer Signature and Badge No.:** \_\_\_\_\_

**SEE REVERSE OF THIS FORM FOR INSTRUCTIONS AND PRIVACY ACT NOTICE**

Fig. 15. —For international shipments of specimens, it is important to include proper forms for importation and exportation, such as the U.S. Form 3-177 required by the United States of America.

preserved specimens should be wrapped with cheesecloth, gauze, or paper towels. A sufficient amount of preservative is then added to keep the specimens and wrappings from drying out. Next these materials are sealed in several plastic bags. Sufficient padding should be provided to protect the bags from being punctured by external sources. Further protection can be provided with an airtight container in the event the preservative escapes from the plastic bags.

Once specimens are properly packed, a shipping label is placed inside and outside of the package. The fourth copy of the loan form is attached to the outside of the package. If the loan involves a foreign country, proper forms for importation and exportation (for example, the U.S. Form 3-177) (Fig. 15) are included with the loan form.

Once a loan is received, it should be checked and the lending-institution should be notified of its arrival and condition as soon as possible. When the material is ready to be returned, the borrowing-institution sends a letter notifying the lending-institution that the loan is being returned under separate cover. The loan is packed and labelled as described above. A reply card is enclosed with the shipment so that the lending-institution can mail it back to notify of the receipt and condition of the loan when it is returned. The card is received by the borrowing-institution and placed in the permanent files with the loan sheet, thus concluding the loan transaction.

When a loan is returned, it should be carefully checked to insure that all specimens were returned undamaged. The specimens should be fumigated before they are returned to their positions in the collection. The specimens are placed in their proper place and the removal slip is taken out. It is also advisable to fumigate the packing material.

### CONCLUSIONS

It is reiterated that the primary consideration in developing any system of storage and organisation for a mammal research collection is the care of each specimen. Considerations of secondary importance are accessibility and working within the resources available. Although the requirements of specimen storage and organisation will vary according to the nature of the material (for example, skin, skeletal material, fluid-preserved material, or other collection items), there are several basic considerations that should prevail throughout the collections. These considerations are :

1. the method of storage and organisation should be simple and logical to promote familiarity to collection workers;

2. standard curatorial procedures (for example, keeping specimens in storage units at all times except during periods of active examination, keeping cases closed, keeping all areas clean, providing thorough and accurate work, conducting pest control activities, and processing loans properly) should be adopted and enforced;
3. once a system of storage and organisation and curatorial procedures are adopted, they should be fully documented and then followed throughout the collection;
4. space in a mammal research collection is a valuable asset and should not be needlessly used on unrelated materials or specimens having no scientific value, particularly when storage of such items compromises the care of the rest of the collection;
5. extensive labelling throughout the collection for the facilities and specimens will promote effective organisation and efficient utilisation;
6. collection staff should be alert to factors and evidence of disorder or physical damage, and immediately take measures to correct problems; collection staff should challenge the methods and materials used for storage and organisation of specimens, and be receptive to progressive changes even if they should be contradictory to traditional techniques;
7. the growth and development of a research collection should be dependent on its ability to provide proper space and care for every specimen in the collection; if a research collection cannot provide the necessary space and care, it should refrain from accepting additional material that would jeopardise the care of already existing material in the collection.

#### SUMMARY

The primary consideration in developing a system of storage and organisation is to protect each specimen from loss or deterioration. Secondary considerations are accessibility and working within the resources available.

Organisation for most specimens usually follows a phylogenetic arrangement to subfamily and an alphabetic arrangement to subspecies with inclusive geographic areas also being arranged alphabetically by decreasing political subdivisions. Further organisational methods may

be required for other parts of the collection, depending on the materials involved. The primary objective is having a designated and predictable location in the collection for each specimen.

Considerations for physical hazards are important in establishing storage and organisation methods to be used in a collection. The planning of space and building facilities is important. Further planning is required for the storage and organisation of skins, skeletal material, fluid-preserved material, and other collection items, specifically type specimens, body mounts and trophy heads, speciality collections, teaching collections, and written records.

Study skins are typically stored in modular cases equipped with a single door and removable drawers. Tanned skins are either placed in cases or hung in special rooms called fur vaults.

Skeletal material may be maintained in various ways depending on the size and method of specimen preparation. Small skeletal material may be placed in appropriate-sized vials or boxes and stored with the study skins. Large skeletal material may be placed on sturdy shelving. Skulls with horns or antlers may be stored on shelves, parallel bars, or screens.

Fluid-preserved specimens are usually maintained in 70% ethyl alcohol or 50% isopropyl alcohol. Specimens may be placed in an assortment of glass jars or larger containers suitable for the purpose. For accessibility and organisation, storage containers may be placed on shelving.

The proper utilisation of specimens in the permanent collection is important. Special attention should always be given to the proper handling of loans.

#### ACKNOWLEDGEMENTS

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#### REFERENCES

- BROMMELLE, N. S. 1968, Lighting, air-conditioning, exhibition, storage, handling and packing: 291-301. IN: *The conservation of cultural property*. UNESCO, *Mus. Monum. ser.*, **11** 1-341.



- BUCK, R. D. 1964. Part I A specification for museum airconditioning. *Tech. Suppl. Mus. News.*, **6** : 53-57.
- COLBERT, E. H. 1961. Inexpensive racks for the storage of large specimens. *Curator*, **4** 368-370.
- COMMITTEE ON SYSTEMATIC COLLECTIONS. 1978. Revised minimal standards, and systematic collections that meet them. *J. Mammal.*, **59** 911-914.
- CORBET, G. B. and HILL, J. E. 1980. *A World list of mamalian species*. viii+1-226. Trustees British Museum Natural History, London.
- DUNDEE, H. A. 1962. A low-cost storage tank for preserved animals. *Turtox News*, **40** 298-299.
- DUNN, W. S. JR. 1970. Storing your collections : problems and solutions. *Tech. Leaflet. Am. Ass. State Local Hist.*, **5** : 1-8.
- FALL, F. K. 1965. New industrial packing materials : their possible uses for museums. *Tech. Suppl. Mus. News*, **10** : 47-52.
- FRILEY, C. E., JR. 1947. Preparation and preservation of the baculum of mammals. *J. Mammal.*, **28** : 395-397.
- HAWKS, C. A., WILLIAMS, S. L. and GARDNER, J. S. 1984. The care of tanned skins in mammal research collections. *Museology, Texas Tech Univ.*, **6** : 1-32.
- HILDEBRAND, M. 1968. *Anatomical preparations*. viii+1-100. Univ. California Press, Berkeley.
- HOFFMEISTER, D. F. 1973. A suggested method of shipping skulls in vials. *J. Mammal.*, **54** : 293-294.
- HONACKI, J. H., KINMAN, K. E. and KOEPPL, J. W. 1982. *Mammal species of the World*. ix+1-694. Allen Press Inc, and Assoc. Syst. Coll., Lawrence, Kansas.
- JACKSON, H. H. T 1926. The care of museum specimens of Recent mammals. *J. Mammal.*, **7** : 113-118.
- JOHNSON, E. V and HORGAN, J. C. 1979. Museum collection storage. *UNESCO Tech. Handbk. Mus. Monum.*, **2** : 1-56.

- KNUDSEN, J. W. 1966. *Biological techniques*. xi + 1-525. Harper and Row, New York.
- LEVI, H. W. 1966. The care of alcoholic collections of small invertebrates. *Syst. Zool.*, **15** 183-188.
- LEWIS, S. D. and REDFIELD, A. 1970. Care of osteological collections. *Mus. Briefs, Mus. Anthrop., Univ. Missouri, Columbia*, **4** i + 1-18.
- LULL, W. P. and MERK, L. E. 1982. Lighting for storage of museum collections : developing a system for safekeeping of light-sensitive materials. *Tech. and Conserv.*, 7(2) : 20-25.
- MACLEOD, K. J. 1978a. Relative humidity : its importance, measurement and control in museums. *Tech. Bull. Can. Conserv. Inst.*, **1** 1-14.
- MACLEOD, K. J. 1978b. Museum lighting. *Tech. Bull. Can. Conserv. Inst.*, **2** 1-13.
- PALMER, R. S. 1946. Plastic vials for storing small skulls. *J. Mammal.*, **27** : 276-277.
- SIMPSON, G. G. 1945. The principles of classification and a classification of mammals. *Bull. Am. Mus. nat. Hist.*, **85**: xvi + 1-350.
- STOLOW, N. 1966a. The action of environment on museum Objects. Part 1 : Humidity, temperature, atmospheric pollution. *Curator*, **9** : 175-185.
- STOLOW, N. 1966b. Fundamental case design for humidity sensitive museum collections. *Tech. Suppl. Mus. News*, **11** : 1-8.
- VAN GELDER, R. G. 1965. "Another man's poison" *Curator*, **8** : 55-71.
- WADDELL, G. 1971. Museum storage. *Mus. News Wash.*, **49** (5) : 14-20.
- WAGSTAFFE, R. and FIDLER, J. H. 1968. *The preservation of natural history specimens*. Volume 2. xv + 1-404. Philosophical Library, New York.
- WHITE, J. A. 1951. A practical method for mounting the bacula of small mammals. *J. Mammal.*, **32** 125.

WILLIAMS, S. L., LAUBACH, R. and GENOWAYS, H. H. 1977.  
A guide to the management of Recent mammal collections.  
*Spec. Publ. Carnegie Mus. Nat. Hist.*, **4** : 1-105.

ZWEIFEL, R. G. 1966. Guidelines for the care of a herpetological collection. *Curator*, **9** 24-35.

#### DISCUSSION

*Q. What simple methods would you use to protect skin and skeletal specimens from the bleaching effect of sunlight in the equatorial region?*

A. The bleaching effect may be reduced by storing specimens away from source of natural light, using curtains or blinds at windows, keeping specimens in closed cases, and using U-V filters (over windows and fluorescent light fixtures).

*Q. What would you recommend for protecting horn material of bovids from the insect damage commonly experienced with rack type storage in tropical countries?*

A. One solution is to paint the horn in polyvinylacetate using an alcohol or acetone solvent. Such method should control insect problems as well as provide reversible treatment. This procedure may be used where problems exist, but it is not recommended as a standard treatment for all specimens with horns.

## COLLECTION-STORAGE AND ORGANISATION WITH SPECIAL REFERENCE TO THE ZOOLOGICAL SURVEY OF INDIA

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### INTRODUCTION

Although the Zoological Survey of India was established in the year 1916, its collection contains some mammalian specimens which are about 150 years old. At the moment, it has acquired the representative specimens from almost all the geographical regions of the Indian subcontinent. It also has specimens collecting of which is at present prohibited. Moreover, there are specimens from the geographical regions where the biota has been destroyed by human activities or natural calamities. The present collection of mammals in the Zoological Survey of India forms the basis of many important published accounts, and specimens from this collection are often needed by scientists of India and abroad for further study or verification of published data. Thus proper storage of the specimens and the organisation of the collection are highly needed. Though there are certain common principles of storage and organisation of the mammalian collection in different centres, there are some differences among these owing to environmental and economic conditions of the countries involved. In the present paper an attempt has been made to discuss the principles of storage and organisation of the mammalian collection and the procedures adopted for this in the Zoological Survey of India.

### GENERAL PRINCIPLES

Proper storage and organisation of the mammalian collection means continued existence of the specimens along with all the attached documents and the same should be readily available for scientific study. To achieve this goal in tropical countries the following factors are to be considered.

#### *Suitable site*

For storing the zoological collection a suitable site is to be selected to reduce the chances of sudden or gradual damage of the specimens. (i) Areas susceptible to flood, earthquake, and other natural calamities should be avoided. An example will be sufficient to explain the point. In 1942, the mammalian collection of the Zoological

Survey of India was shifted from Calcutta to Varanasi under war emergency. Then came the most unfortunate happening, i.e. the flood of the Varuna river at Varanasi in September 1943, when major part of the collection was submerged under water for about three days. Many specimens were lost and many, which were badly damaged, were finally rejected. (ii) Too arid or humid areas with extreme climatic conditions are also unsuitable, as to protect the collection in such areas require much financial involvement. (iii) Industrial belt is to be avoided to minimise the reaction of different gaseous by-products on the preserved specimens. (iv) International border area should not be selected, as this may involve sudden shifting of the collection and other connected hazards in case there is a war.

### *Permanent building*

Occasional shifting of the collection from one building to the other means considerable loss, damage, and misplacement of specimens. In fact mammal collection of the Zoological Survey of India had been subjected to the effect of transit on several occasions and in spite of utmost care there was loss and damage at all the times. This can only be prevented by housing the collection in its own building instead of a rented one. The design of the building is to be planned according to the climatic conditions of the area, so as to minimise the effects of wind, heat, humidity, rain, etc. Instead of small rooms, it is better to have big halls which help in the arrangement of collection cabinets in rows, and in space-economy. Sufficient space is to be kept reserved as a provision for the storage of fresh material obtained from the future surveys or other sources.

### *Space*

Keeping of a large number of specimens one above the other in a drawer or in a container is responsible for the damage of the tail, ears, vibrissae, limbs and attached labels of the specimen. Moreover for taking out a particular specimen from a lower row, the entire arrangement in a particular container is disturbed. Due to the shortage of space, often steel trunks or boxes containing the specimens are kept one above the other or in shelves of steel racks. Under these situations more man-power is required for curatorial and maintenance work and many of the containers are not likely to be checked year after year. Further, display of specimens for the public education is only possible when there is sufficient space. Furthermore, it is preferable that the entire collection, office and laboratories should be housed in the same campus. Thus for the proper arrangement of the specimens and regular curatorial work, sufficient space is needed.

### *Containers*

According to the nature of preservation (wet or dry) and size of the specimens, proper containers are to be selected. For fluid-preserved specimens, glass jars of different sizes with air-tight lids are most suitable. Different types of steel cabinets with movable trays, or drawers, steel racks, steel trunks, wooden and card-board boxes, glass cases, etc., are required for dry specimens. To keep the skulls of smaller sizes, plastic vials with lid of suitable material or skull bags can be used. Details of different type of containers used in different centres, their positive and negative sides, etc., have been discussed by Colbert (1961), Dundes (1962), Knudsen (1966), Long (1970), Lewis and Redfield (1970), Palmer (1974), Dowler and Genoways (1976), and Williams *et. al.* (1977).

### *Regulation of climatic factors*

Excessive moisture, dryness, sunlight, temperature, etc., are potential threats to the preserved specimens and their labels. Rapid fluctuation of the above factors are also detrimental to the collection. Sunlight causes the most damaging effect ; the ultraviolet and the bluish portion of the visible spectrum have the greatest ability to stimulate the chemical changes. The ideal condition of the climatic factors is different for different types of specimens. Jackson (1926) mentioned 21°C as being a proper temperature for fluid and osteological material. Van Gelder (1965) opined that daily temperature fluctuation in the storage area should not exceed 8.3° C. It appears that 50-60% Relative Humidity is ideal for the storage area. Thus, air conditioning and humidity control of the storage area are desirable. Use of curtains and fluorescent lamps with acrylic filters will minimise the action of light (Stolow 1966).

### *Antifire measures*

Dry skins and the different chemicals used in the preparation and preservation of mammalian specimens are highly inflammable. Thus, proper antifire measures in the storage area are a must. Foam-type fire extinguishers are to be kept in different parts of the storage area, so that these can be used at the time of emergency. Local regulations for fire prevention inside the cabinets and racks are also desirable. Fire insurance for the collection is not possible in developing countries having limited budget. Moreover, it is not possible to assess the commercial value of zoological collections, and many of the specimens cannot be replaced by money.

*Atmospheric pollutants*

In the tropical countries, in addition to its normal components, air contains dust, moisture, sulphur dioxide, carbon dioxide, soot and spores in good quantities. All of these are responsible for the damage of specimens, labels, and containers. Moulds normally grow at a Relative Humidity of 80% and temperature above 20°C, a condition available in most parts of the year in tropical countries. Thus, proper vigilance is to be kept to reduce the entry of atmospheric pollutants in the storage area.

*Arrangement of specimens*

This is the most fundamental issue in the storage of a zoological collection. Lack of proper arrangement of the specimens makes the entire collection good-for-nothing. According to Zweifel (1966) there are basically two different ways of arrangement of zoological specimens, viz., (i) by catalogue number and (ii) by zoological classification. Numerical arrangement requires a species index that lists the species represented in the collection and catalogue number of all the specimens. Without such an index, it would be necessary to search through the entire collection or the numerical catalogue in order to assemble all representatives of a particular taxon. Moreover, in numerical arrangement, if a container is misplaced, it is practically lost. In collections arranged according to zoological classification, misplacement is immediately detected from the name on the container. It is also more economical in space, as a number of specimens of the same taxon can be stored in one container, with labels on each.

*Specimen cards*

Specimen card for each specimen with all the details, viz., sex, locality, date of collection, collector or donor, condition of the specimen, registration or catalogue number, external and cranial measurements, keeping place, etc., should be prepared and arranged in a card cabinet according to the zoological classification. Consultation of these cards will often serve the purpose of the scientists and reduce the incidences of handling and removal of the specimens from storage.

*Man-power*

Most of the museums in developing countries do not have the technical facilities of storage, such as proper container, sufficient space, regulatory mechanism for atmospheric factors, etc. These drawbacks can only be neutralised to some extent by manual labour with sufficient man-power.

## STORAGE IN THE ZOOLOGICAL SURVEY OF INDIA

The Zoological Survey of India is responsible for the storage and maintenance of the National Zoological Collections of India. The mammal and osteological collections at present contain about 22000 identified specimens including nearly 400 types. The major part of this collection is maintained for scientific study and comparison, while a small part is displayed in the zoological galleries of the Indian Museum. At the moment, the collection is housed in three different buildings in Calcutta, owing to the acute shortage of space. According to the nature of preservation, the entire collection may be divided into the following categories.

(i) Dry flat skins, (ii) dry rolled specimens, (iii) mounted specimens, (iv) wet specimens, (v) osteological material, (vi) anatomical parts like bacula, testes, ovaries, etc.

To keep these huge collections, different types of containers used. These are briefly discussed below :—

*Wooden cabinets*

There are 48 wooden cabinets (Fig. 1A) containing chest of drawers of different sizes and depths. and with glass tops. The drawers can be taken out from the cabinet for study and arrangement of the specimens.



Fig. 1 A.—Rows of wooden cabinets containing dry specimens of mammals.



*Steel cabinet*

There is a glass-door steel cabinet with horizontal shelves.

*Steel racks*

There are 50 steel racks (Fig. 1B) with a number of movable shelves.

*Jars*

Glass jars of different sizes, with bakelite or glass lids.

*Glass cases*

Wooden or steel cases fitted with thick glass panes are used in the zoological galleries of the Indian Museum.

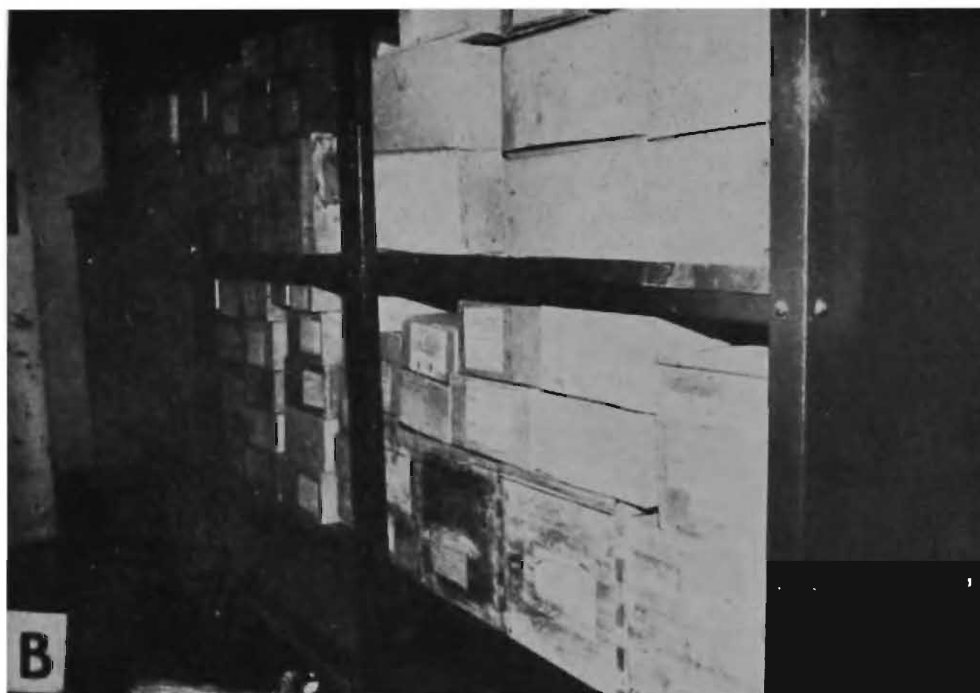


Fig. 1 B.—Steel rack with movable shelves containing osteological material in wooden or card-board boxes.

In addition to the above, a large number of steel trunks, wooden or card-board boxes, plastic vials and skull-bags of various sizes are also used (Fig. 2A).

Flat skins and rolled specimens are kept in steel trunks, wooden or card-board boxes or in drawers of cabinets, according to their sizes. Each container usually contains specimens of the same species, but sometimes for the economy of space, specimens of the allied species are also kept in the same container, with or without partition between them.



Fig. 2 A.—Different types of small containers used mainly for keeping osteological material.

Skulls are either tied with the respective skins after putting the same in the skull bag, or are kept separately in a glass vial and placed in the same container (Fig. 2B). At the top of each cabinet, there is a small metallic holder in which a hand-written label is inserted, showing the order or family to which the specimens of the cabinet belong. The inner surface of the door of cabinet bears a label which is a guideline to the contents of each drawer. To indicate the contents of the box or trunk, a paper label is either pasted on its outer surface or tied to the latch by means of a thread. It was found that the latter system is better than pasting the label with gum.

Wet specimens are stored in glass jars of different sizes, having 90% ethyl alcohol or 4% formaldehyde solution as preservative, and placed in the shelves of the steel racks. It was found that bakelite lids prevent the evaporation of alcohol to a great extent but easily crack.

Osteological collection ranges in size from the skull of a shrew to the entire skeleton of a whale or elephant, along with a lot of unidentified



Fig. 2 B.—Arrangement of specimens in a wooden drawer of a wooden cabinet.

material. Generally, the skeletal material of each specimen is kept separately in a steel trunk or wooden/card-board box depending on its size, and placed in the shelf of the steel rack (Fig. 1B). Sometimes more than one skeleton of the same species or allied species are kept separately in small containers and then collectively placed in a steel trunk. Each small container bears a label, and the label on the outside of the trunk shows the total contents. Large osteological material particularly the skulls are kept open on the shelves. A good number of skulls belonging to the order Artiodactyla are suspended on the wall of zoological galleries of the Indian Museum by means of hooks (Fig. 3A).

Mounted specimens or skeletons prepared for display are kept in the glass cases or hung from the roof of the large mammal hall by steel rods (Fig. 3B). However, the materials suspended to the wall or hung from the roof or kept open on the shelves are more exposed to dust and mechanical damage.

Bacula, testes, ovaries, etc., whenever extracted for study are kept in glass vials or mounted on glass slides. These are either stored in cardboard boxes with cotton padding or in slide boxes. Each extracted



Fig. 3 A.—Skulls hung from the wall of the large mammal gallery of the Indian Museum.

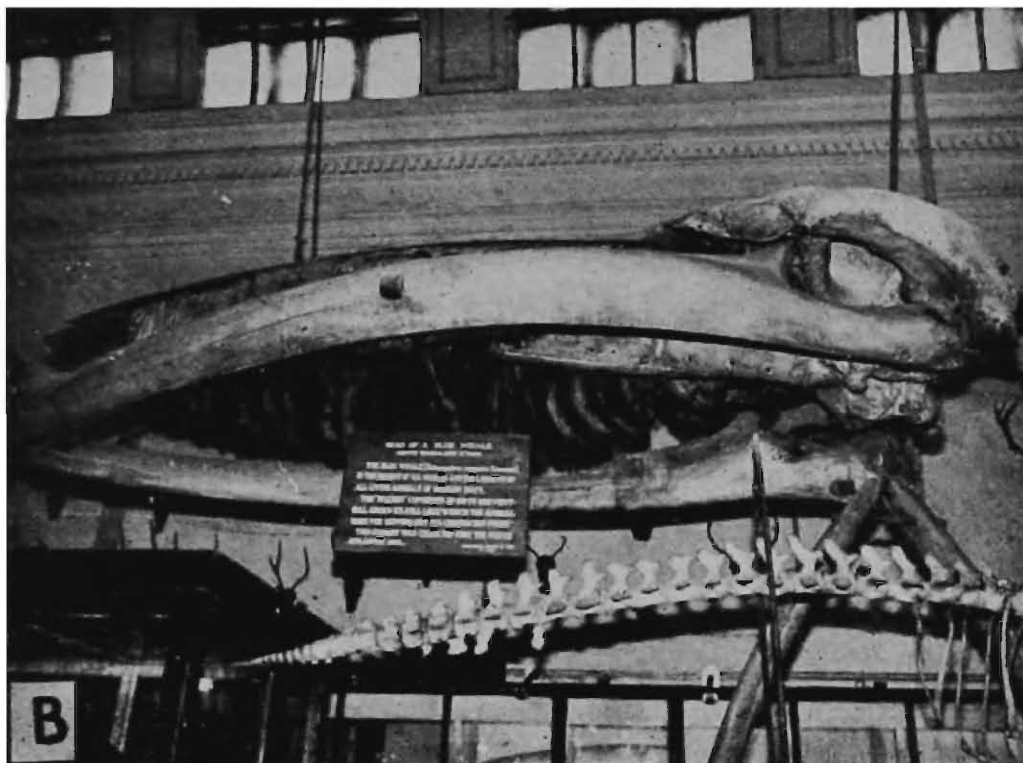


Fig. 3 B.—Osteological material hanging from the roof of the large mammal gallery of the Indian Museum.

anatomical part bears the same registration number as that of the specimen from which it was extracted and separate entries made on the original label.

Special care is taken for the storage of type-specimens which are kept separate from the general collection. One steel cabinet and one wooden cabinet with lock and key arrangements are used for the storage of type specimens and the cabinets are kept in the cubicle of the Officer-in-Charge of the Mammal and Osteology Section. Flat skins or rolled specimens are wrapped with tissue paper. Skulls are kept in a special type of small card-board box, with glass top. The specimens of a particular type series along with the skull box are then placed in a card-board box of the required size and stored in a drawer of the wooden cabinet. Type-series of the allied taxa are kept in the same drawer, with proper labels. Wet type-specimens are kept in the glass jars of required sizes, with 90% ethyl alcohol and placed on the shelves of the steel cabinet. Type-series of a particular taxon are kept in a jar, with an outside as well as an inside label, in addition to the individual labels of the specimens. If the skull of a type specimen has not been extracted by the describer, it is allowed to remain as such unless required for study. Extracted skulls are kept in the jar of the respective specimens but in separate glass vials. Type cards with all the details of the type specimens are prepared and maintained in a card cabinet.

Ecto or endoparasites collected from specimens in the field, after proper preservation, are sent to the respective specialists of the department for identification, study, and storage.

Arrangement of the general dry collection is made according to the listing of the species and subspecies in the 'Checklist of Palaearctic and Indian Mammals' by Ellerman and Morrison Scott (1951). Specimens of the same species or subspecies are arranged according to the country of collection. Specimens belonging to the same country are further grouped according to the alphabetical order of the collecting provinces. However, for the dry and wet type specimens numerical arrangement is adopted. It is done according to the catalogue number as shown in Khajuria *et al.* (1977).

Foam-type of fire extinguishers are maintained at different corners of the storage area as a preventive measure against fire. On a certain festival day of the year, trained persons from the antifire department are posted near the storage area to prevent the hazards due to fireworks, if any.

For the sake of convenience and regular supervision of the collection, office, laboratory, mini-store of chemicals and collecting material, library of important journals and books, steel cabinets containing specimen cards and other documents are maintained in the same floor in which the major part of collection is stored.

From the comparison of principles and practice, it becomes obvious that though proper attention is being paid to curatorial work and special care is taken for the protection of collection against pests, dust, fire, etc., but practically nothing could be done to regulate light, temperature, humidity and other atmospheric pollutants. However, Zoological Survey of India is going to have its own multistoried building in Calcutta in near future and planning has been done to replace the wooden cabinets by special type of steel cabinets with trays of different depths. Attempts will also be made to aircondition the entire area of storage.

#### SUMMARY

Proper storage of large zoological collection means continued existence of specimens in good condition along with all the attached documents and easy availability of the same for scientific study and comparison. To achieve this goal in a tropical environment, the following are the minimum requirements. (i) selection of suitable site and building to house the collection, (ii) sufficient space for arrangement and display, (iii) proper containers for different types of specimens, (iv) arrangements for the regulation of light, temperature, humidity and wind, (v) antifire measures, (vi) protection against insects, dust and other atmospheric pollutants, (vii) arrangement of specimens in a standard manner, (viii) ready supply of preservatives and other chemicals, (ix) preparation and maintenance of specimen-cards and (x) man-power for regular curatorial work. At the moment, the mammalian collection of the Zoological Survey of India are housed in three different buildings in Calcutta. The storage is done in wooden cabinets and steel racks. On the shelves of steel racks specimens are kept in steel trunks, wooden boxes, card-board boxes, glass jars, etc., of different sizes. Some of the osteological material and the mounted heads are also kept open on the shelves or hanging from the wall with the help of hooks. Mounted specimens are stored in glass cases of the galleries of the Indian Museum, for display. The alcohol-preserved type specimens are stored in steel cabinets which are kept separately from the general collection, under special care. Bacula, testes, ovaries and other body-parts, whenever extracted for study, are kept in small glass vials with plastic lids. These vials are stored separately in card-board boxes with cotton padding, and separate entries in this respect are made on original labels. Ecto- and endoparasites collected from the specimens are either preserved in alcohol or mounted on glass slides and handed over to respective specialists of the department for study and storage. Arrangement of the specimens of the Indian subcontinent is done, as far as possible, according to the arrangement of species adopted by Ellerman and Morrison Scott (1951). For the sake of convenience and regular supervision of the collection, laboratory, mini-store of chemicals and collecting material, sectional library, steel cabinets containing specimen cards and other

documents are maintained in the same floor in which the major portion of the collection is stored. Though proper attention is paid to curatorial work and special care is taken for the protection of the collection against insect pests, dust, and fire, practically nothing could be done to regulate light, temperature, humidity, and other atmospheric pollutants in the collection storage area. However, the Zoological Survey of India is going to have its own multistoried building in Calcutta in near future and planning has been done to replace the wooden cabinets by steel cabinets with movable trays of different depths. Attempts will also be made to air condition the entire area of the collection-storage.

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#### REFERENCES

- COLBERT, E. H. 1961. Inexpensive racks for the storage of large specimens. *Curator*, **4** : 368-370.
- DOWLER, R. C., and GENOWAYS, H. H. 1976. Supplies and suppliers of vertebrate collections. *Museology, Texas Tech. Univ.*, **4** : 1-83.
- DUNDEE, H. A. 1962. A low-cost storage tank for preserved animals. *Turtlex News*, **40** : 293-299.
- ELLERMAN, J. R. and MORRISON-SCOTT, T. C. S. 1951. *Checklist of Palaearctic and Indian mammals*. Brit. Mus. Nat. Hist., London.
- JACKSON, H. H. T. 1926. The care of museum specimens of recent mammals. *J. Mammal.*, **7** : 113-118.
- KHAJURIA, H., CHATURVEDI, Y and GHOSAL, D. K. 1977. Catalogue Mammaliana. *Rec. zool. Surv. India, Occ. Pap. No. 7* : 1-45.
- KNUDSEN, J. W. 1966. *Biological techniques for collecting, preserving, and illustrating plants and animals*. Harper and Row, New York.

- LEWIS, S. D. and REDFIELD, A. 1970. Care of osteological collections. *Mus. Briefs, Mus. Anthr. Univ. Missouri-Columbia*, **4** : 1-18.
- LONG, C. J. 1978. *Museum workers notebook*. San Antonio, Texas.
- Palmer, W. M. 1974. Inexpensive jars for museum specimens. *Curator*, **17** : 321-324.
- STOLOW, N. 1966. The action of environment on museum objects. Part II : Light. *Curator*, **9** : 298-306.
- VAN GELDER, R. C. 1965. Another Man's poison. *Curator*, **8** : 55-71.
- WILLIAMS, S. L., LAUBACH, R. and GENOWAYS, H. H. 1977. A guide to the management of recent mammal collections. *Spec. publs., Carnegie Mus. nat. Hist.*, **4** : 1-108.
- ZWEIFEL, R. G. 1966. Guidelines for the care of a histological collection. *Curator*, **9** : 24-35.

#### DISCUSSION

- Q. With space consideration so important, has ZSI developed a protocol on how field-preparation should be done so that there is some assurance that a specified number of specimens of each species taken will be prepared by different procedures ?*
- A. Before going to the field we make a list of species likely to occur in that region. Four specimens of each species are generally collected, out of which two are preserved in fluid and the other two are rolled. Body of any additional specimen is converted into skeleton.
- Q. I have noticed open unscreened windows in your present collection-facilities. Do you think it would be safer for storage protection to take effort to prevent potential insect-pests from entering your facility ?*
- A. We have screens for the windows. At the time of your visit, those were removed for periodical cleaning.





## **FIELD FIXATION AND STORAGE OF FLUID PRESERVED SPECIMENS FOR MUSEUM MAMMAL COLLECTIONS**

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### **INTRODUCTION**

Traditional museum collections of mammals include large numbers of specimens stored whole or in pieces in some type of preservative. Most commonly, these specimens have been “fixed” by either immersion or injection with formaldehyde and later washed with water and then stored in a dilute (70%) ethyl alcohol. Historically, such formaldehyde-fixed specimens have proven to be extremely valuable to mammalogy. In the nineteenth and early twentieth centuries, when comparative gross anatomy was especially popular and the modern science of systematics was in its infancy (as taxonomy), fluid specimens were widely used for research. From this beginning, museums have continued over the years to acquire, accession, catalogue, and store thousands of fluid specimens. Most collections have increased in size and the methods of fixation and storage have remained essentially unaltered even though both the pace and types of research have changed dramatically.

Regardless of how mammalogy has changed, the original type of fluid preservation was reasonably successful and certainly was not short-sighted. In fact, the obvious purpose of a fluid collection—to obtain and store specimens for both current and future research—clearly was achieved. Many of the specimens fixed in formaldehyde eighty to one hundred years ago, still are suitable for a variety of forms of gross anatomical investigations, particularly those involving myology, and a reasonable percentage can be used—albeit with limitations—for histological analysis. On the other hand, it certainly is time for us to now reconsider our scientific needs and ask the question “how best can we prepare for the future?”

With the foregoing in mind, the purposes of the present paper are to: (1) review resources; (2) consider future needs; (3) review some of the basic techniques; (4) present a selection of available techniques that could become routine additions to museum technology throughout the world, and (5) review some aspects of collection storage.

## RESOURCES

In the present brief paper it obviously would be impossible to fully discuss or even mention in passing all of the various techniques available for histology and histochemistry and other types of microscopic research with value to mammalogy. On the other hand, it seems unlikely to me that a great number of these techniques ever will gain wide-spread acceptance as routine museum technologies because many are difficult or impossible to use in the field and some are probably too highly refined for common usage.

We are indeed fortunate that many reference books are available and any particular, specific fixation problems that arise for non-routine projects usually can be solved fairly quickly. Ideally, each museum collection library should shelve one or more of these works. Among the available books, I especially recommend the following : Lillie and Fullmer (1976); Culling (1974); Gray (1973); Humason (1979); Kiernan (1981); and Chayen *et al.* (1973). Additionally, in 1979, the American Society of Ichthyologists and Herpetologists issued a special "curation report" that so far exceeds any similar information published for mammals. This mimeographed report is available from the Smithsonian Oceanographic Sorting Center, Washington, D.C. 20560 and summarises very clearly the conventional fixation and storage methodologies for fluid specimens.

Lastly, the reader also is advised to consult three excellent chapters published fairly recently in *Mammal Review* (Brown and Stoddart, 1977; Brown and Hilton, 1979; Brown, 1979) and a chapter by Forman and Phillips (1985) in a book on ecological methods. These papers deal specifically with histological and histochemical techniques for mammalogists and form an outstanding resource for those who are interested in fluid collections for museum-based research.

## FUTURE NEEDS

One unfortunate feature of our collective scientific future will be the extreme difficulty of obtaining specimens for research. Indeed although it is an unpleasant idea for those of us interested in the study of wild species, it nevertheless is clear that many species either will become extinct or extremely uncommon in native habitats in the near future. Therefore, any consideration of future research must center on the expected scarcity of specimens and, consequently, the importance of being able to obtain as much data as possible from each specimen.

What kinds of future data might we, or our successors, wish to obtain from specimens collected now ? Although we cannot answer this question with any degree of certainty, some ideas can be gained by

analysing research trends. With this in mind, it seems clear that developments in cell and molecular biology are the most likely candidates for application to mammal museum collections. Over the past several decades, we have seen a progression in which standard histology, histochemistry, and recently, cell ultrastructure, have been applied to problems in mammalogy. A very few selected examples, which serve to illustrate this point, are mentioned here. Histology of integumentary glands of rodents has been used for systematic analysis (Quay, 1968). Histological and histochemical techniques have been used to analyse and compare the gastric mucosae of mammals (Swarup *et al.*, 1971, Forman, 1971, 1972). Histological comparisons of reproductive tracts have proven especially interesting (Gopalakrishna and Murthy, 1960, Karim, 1975, Hood and Smith, 1983) and have been used as a significant foundation for cladistical analysis of relationships (Hood and Smith, 1982). Histochemistry has been used to document changes in integumentary enzyme activity before and during hibernation (Sokolov and Dzhemukhadze, 1982). Very recently, transmission electron microscopy has been employed to compare cell structures within tissues in order to unravel evolutionary pathways and systematic relationships (Phillips and Studholme, 1982, Tandler *et al.*, 1983; Phillips *et al.*, 1984). Aside from these trends, in which increasingly more sophisticated microscopic analysis is apparent, it also now is noteworthy that ethanol-preserved tissues have been found to be suitable for extraction of nuclear DNA and for DNA-DNA hybridization and analysis of phylogenetic relationships (Sibley and Ahlquist, 1981). All of these studies could have been based on museum collections (indeed, most were) and perhaps are representative of the future for fluid collections.

In summary, it seems likely that chemically-based techniques will become increasingly available for general use by mammalogists and that although we cannot predict exactly what these techniques will require, we nevertheless should attempt now to set the stage for future work along these lines. To simply continue old practices by themselves is to risk losing major opportunities for future scientists and to put unfortunate limitations on museum collections.

#### FIXATION

Fixation is a process by which tissues are altered into a stable configuration, often by the cross-linking of protein chains so that they are denatured and deactivated. It is essential to understand that any form of fixation (chemical or otherwise) creates a controlled artifactual condition that allows for both storage (sometimes limited) and study within a set of parameters that are established by the fixative itself. In other words, once tissues have been fixed, they no longer are "natural," instead they are the product of fixation and it is that product that actually

is studied. With this in mind, it is clear that the fixation process determines the limits of what can be learned with various types of analyses.

The fixation process generally tends to "harden" tissues (within limits) so that they can be more readily embedded and sectioned for histology. Additionally, the fixation process also inactivates autolytic enzymes, prevents bacterial decay, insolubilises tissue components, and affects the extent to which either shrinkage or swelling can occur during processing.

Selection of fixatives suitable for museum collections thus is partly dependent on the suitability of the particular chemical artifact created by the process itself. One reason why formaldehyde has remained so popular for so long is that not only is it easy to use and available, but, additionally, its effect on tissue is such that a wide variety of options are left open when research is carried out.

Aside from selecting the most appropriate fixative, perhaps the actual application of the fixative is the most important step in the entire process. Generally speaking, preparation of fluid specimens is a process that is treated very casually by field mammalogists. Frequently, specimens that have been dead for as long as thirty minutes are placed *in toto* in containers of formaldehyde solution. On the one hand, specimens that have been treated so casually still are valuable in that their gross anatomy can be studied later in the museum laboratory. However, if any hope of future histological or histochemical study is to be fulfilled, considerable care must be exercised at this stage of the preparation process.

For quality microscopic study, it is essential for the fixation process to begin simultaneously with, or even before, the death of the specimen. Additionally, because the fixative does not penetrate tissues instantaneously, it is advisable that tissues be brought into physical contact with the fixative as quickly as possible. Consequently, the standard museum procedure—injecting 10% formalin at scattered sites or opening the abdominal cavity, or both, and then placing the specimen in a container of formalin—is far too crude for most current microscopic research and one can logically assume that future research also will suffer from this procedure.

Several alternatives suitable for field work can be fairly easily incorporated into a typical field schedule. For example, at death the thoracic and abdominal organs can be removed and immersed directly in fixative. Large or compact organs (i.e., liver and kidney) can be sliced open and in those organs that have large lumina (i.e., the digestive tract), the fixative can be injected into the lumen itself.

Perfusion with a fixative can be done fairly simply, without elaborate equipment (Quay, 1974). The advantage of perfusion, of course, is that the fixative utilises the circulatory pathway to reach tissues. The procedure recommended by Quay (1974) employs large syringes with needles of varying sizes. A five minute perfusion would require 100 ml or more of perfusate. A major vein, such as the jugular, is opened following anaesthetisation (sodium pentobarbital is an excellent choice). Fixative next is injected into the left ventricle of the heart. The needle should be clamped to the wall of the heart to prevent its escape under pressure. Ringers' solution, or 0.85% saline, can be injected into the left ventricle until the effluent from the jugular is clear. Caution must be taken not to inject these fluids into the animal under high pressure as this could introduce artifacts into the tissue. Kiernan (1981) has described a slightly more elaborate apparatus for perfusion in small mammals, but yet one that could be readily adapted to field conditions. Two containers, one with normal saline and one with fixative, are placed 1 meter above the specimen. Tubes exiting from the bases of the containers are closed-off with pinch clamps and joined to a Y-connector that leads to a syringe. Saline solution is allowed to flow first into the heart. When the outgoing liquid is clear, the pinch clamp to the fixative is opened and that to the saline is closed. This procedure prevents the serious problem of introducing air into the cardiovascular system, which may occur when syringes are used by themselves. In theory, any fluid fixative can be used for perfusion, however 10% neutral buffered formalin (NBF) is the fixative of choice for general histology and histochemistry. Quay (1974) has provided ample visual evidence that excellent histological results can be obtained by perfusing in small mammals in this way.

As a summary, I have listed below seven specific "hints" that should be kept in mind while fixing tissues for light microscopic histology or histochemistry.

- (1) Fix as small a piece of tissue as possible; briefly fix large pieces of very soft tissues (15-30 mins.) until they harden enough to be sliced without unduly compressing them.
- (2) Very soft tissues (e.g., bone marrow) can be wrapped in porous paper (filter paper) prior to immersion.
- (3) Lumina should be opened; thin or tubular pieces that may roll or invert should be attached to paper against their outer walls.
- (4) Intratracheal injection of fixative is essential for lung tissue if perfusion is not performed.

- (5) Tissues should never be so large as to be compressed or bent by the container.
- (6) The rate of penetration of tissue by fixatives varies inversely with temperature, however, low temperature retards or arrests autolytic changes and therefore may actually result in the best fixation.
- (7) Plastic or other non-metallic instruments must be used when handling tissues in fixatives containing  $\text{HgCl}_2$ .

Fixation for transmission electron microscopy (TEM) poses special problems because if one wishes to study the infrastructure of individual cells, then the entire fixation process becomes even more critical. Ideally, perfusion undoubtedly is the best approach but within the constraints of field work and the typical fixatives used, perfusion is not always practical. In my laboratory, we have successfully adapted the following procedure for field work. First, the animal is anesthetised with sodium pentobarbital (50 mg/ml). Next, a polyethylene tube is passed into the stomach via the mouth and esophagus. This tube is connected to a small (1cc) syringe containing fixative, which is injected into the digestive tract. The specimen absorbs the fixative but does not die immediately so that other organs (i.e., salivary glands, eyes, thyroid glands) can be removed and minced into small pieces (1x1 mm) in fixative. The mincing must be done carefully (dental wax or a sheet of moderately hard plastic makes a good substrate) with a sharp scalpel blade or a single-edged razor blade. If care is exercised and organs are removed without causing major bleeding (i.e., by tying off major arteries if necessary), a wide variety of organs can be removed successfully. Lastly, the digestive tract can be excised and individual components minced while immersed in fixative. At this point in the discussion, it would be worthwhile to mention that many fixatives are extremely dangerous (some, such as formaldehyde, are potential carcinogens) and proper precautions always should be exercised when fixing specimens in the field, away from laboratory-type fume hoods. We routinely carry a supply of rubber surgical gloves as part of our field gear because the TEM trialdehyde fixative contains DMSO and thus is very quickly absorbed by the body.

#### FIXATIVES

The fixatives discussed in the following paragraph (as well as those not discussed in detail) are summarised in Table 1. The purpose of this table is to provide an easy reference, beyond the text itself. Although limited in number, these particular fixatives were selected because of their—(1) adaptability to field work; (2) relative ease of handling and storing; and (3) likely value to future research. Many additional,

**TABLE 1. A general summary of eight fixatives that are especially useful in mammalogy and which could easily be adapted for routine museum use**

Name	Formula	Use	Special Instructions
Bouin's	25 ml 40% formalin; 75 ml saturated aqueous picric acid; 5 ml glacial acetic acid.	General purpose; reproductive tracts; skin; connective tissue; gastrointestinal tract.	Fix 24 hours; store in 70% ETOH.
Carnoy II	60 ml 100% ETOH; 30 ml chloroform; 10 ml glacial acetic acid.	Bone; cartilage (chondroitin sulfates); nuclei; carbohydrates; fibrous proteins; mast cells (histamine); histochemistry of proteins.	Fix 6-8 hours; 2-3 hour wash in 100% ETOH (remove chloroform).
Helly's	5 g Hg Cl <sub>2</sub> ; 2.5 g K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> ; 1 g Na <sub>2</sub> SO <sub>4</sub> . 10 H <sub>2</sub> O 100 ml H <sub>2</sub> O.	Hemopoietic; hypothalamic; neurosecretory material (NSM); mitochondria; myelin; endocrine organs; intercalated discs; bone marrow.	Fix 12-24 hours.
NBF (neutral buffered formalin)	100 cc 40% formalin; 900 cc H <sub>2</sub> O; 4 g acid sodium phosphate (monohydrate); 6.5 g anhydrous disodium phosphate.	General purpose; muscle; connective tissue; glands; gastrointestinal tract.	Fix 24-48 hours; wash with H <sub>2</sub> O and store in 70% ETOH.
Sanfelice	80 ml 1% CrO <sub>3</sub> ; 40 ml 40% formalin; 5 ml glacial acetic acid.	General purpose; nuclei; chromosomes.	Mix immediately before use; fix 24 hours; wash thoroughly in running water.
Susa (Heidenhain's)	45 g HgCl <sub>2</sub> ; 5 g NaCl; 20 g Trichloroacetic acid; 40 ml glacial acetic acid; 200 ml 40% formalin; 1000 ml H <sub>2</sub> O.	General microanatomy; mitochondria; connective tissue; myelin; neurosecretory material.	Fix 24 hours; transfer to 95% ETOH.



Name	Formula	Use	Special Instructions
Trialdehyde	5 g paraformaldehyde dissolved in 25 ml H <sub>2</sub> O with a drop of NaOH. Add 15 ml 50% glutaraldehyde, 6.25 ml DMSO, 0.25 ml of 0.1 M CaCl <sub>2</sub> , 2.5 ml acrolein, and dilute to 250 ml with 0.05 M cacodylate buffer with 0.1 M sucrose (makes 250 ml; use fresh daily)	Ultrastructure; organelles, cell membrane; also good for light-level histochemistry.	Fix 10-24 hours; replace fix with 3% glutaraldehyde and store at 4-5 °C or, in field, store at ambient temperature in 0.05 M cacodylate buffer with 0.01 M sucrose.
Zenker's	Stock; 2.5 g K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> ; 5 g HgCl <sub>2</sub> ; 1 g Na <sub>2</sub> SO <sub>4</sub> ; 100 ml H <sub>2</sub> O <hr/> 5 ml glacial acetic acid is added just before use.	General microanatomy; cell organelles.	

specific types of fixatives are available and the reader is referred to the many handbooks for formulae and detailed information about them (e.g., Lillie and Fullmer, 1976; Gray, 1973; Kiernan, 1981).

### *Histology and Histochemistry*

Formaldehyde deserves special consideration here because of its popularity and wide-spread use. Formaldehyde usually is available commercially as a solution of gas and water such a mixture contains from 37 to 40% formaldehyde gas, by weight, and usually is called "formalin" or "formaldehyde." Some confusion has been caused by the fact that this commercial preparation frequently has been treated as though it were a 100% formaldehyde solution. Consequently, the "10%" formalin used by museums actually is a 4.1-4.5% solution (Lillie and Fullmer, 1976). It is important to keep this peculiarity in mind while interpreting fixation techniques described in literature because an actual 10% solution is significantly different from the "10%" solution used by many people. For example, a 4.5% ("10%") formalin solution will adequately fix tissue in 48 hours at 20-25°C, whereas an actual 10% solution can harden tissues adversely in the same time period at the same temperature. In

any case, heat will increase the action of the fixative (Lillie and Fullmer, 1976). Generally speaking, the best formaldehyde fixation is obtained by long exposure at low temperatures, so if refrigeration or ice are available, a cold (0-5°C) 4.1-4.5% ("10%") formalin solution could be expected to give the best results.

Commercial formaldehyde usually contains traces of methanol and formic acid, and additional formic acid can be formed as a result of oxidation. An acidic formalin solution can inhibit histological staining reactions (azure-eosin, for example) and, therefore, formalin usually is most useful when it has been buffered. When calcium carbonate is added (in excess) to a formalin solution, the pH should rise to between 6.3 and 6.5. Not only is this approximate, but also it must be remembered that the pH will fall again as the tissue is fixed (Lillie and Fullmer, 1976). Neutral buffered formalin, which is preferable if pH is regarded as critical for research purposes, can be prepared as follows: 100 cc 40% commercial formaldehyde solution, 900 cc water, 4 g acid sodium phosphate, monohydrate; and 6.5 g anhydrous disodium phosphate. This mixture should be pH 7.0.

For field collecting, the polymerised form of formaldehyde has several advantages. The most significant of these are weight and purity. The polymerised form, paraformaldehyde, comes as a powder that can be easily transported to a field site and then prepared on demand; 35 g of paraformaldehyde powder in 1 liter of water will yield a 4% (by weight) solution, which is equivalent to the standard "10%" formalin fixative. The paraformaldehyde powder is added to boiling water along with a few drops of sodium hydroxide (NaOH), which acts as a synergist. The 4% paraformaldehyde solution will lack formic acid and methanol and if light-level immunocytochemical analyses are contemplated, it could be the fixative of choice.

Table 1 contains formulac for several other fixatives that are broadly useful for histology and are suitable for museum collections. Bouin's fluid remains in fairly wide use, although Gray (1964) felt that; (a) its only advantage might be that tissues can remain in it for lengthy periods (but even so, immediate storage in 70% ETOH is desirable); and (b) it may have the disadvantage of causing formation of vacuoles in cells. Additional general fixatives (Table 1) which should be considered include Zenker's, Sanfelice, Susa (Heidenhain's), and Helly's. As with any fixative, attention should be given to fixation times and wash and storage procedures. Mercuric chloride must be removed following fixation and, where rapid penetration is important (large pieces of tissue; rapid autolysis), Carnoy II should be employed. Another mixture that is widely recommended for large pieces of tissue because it penetrates

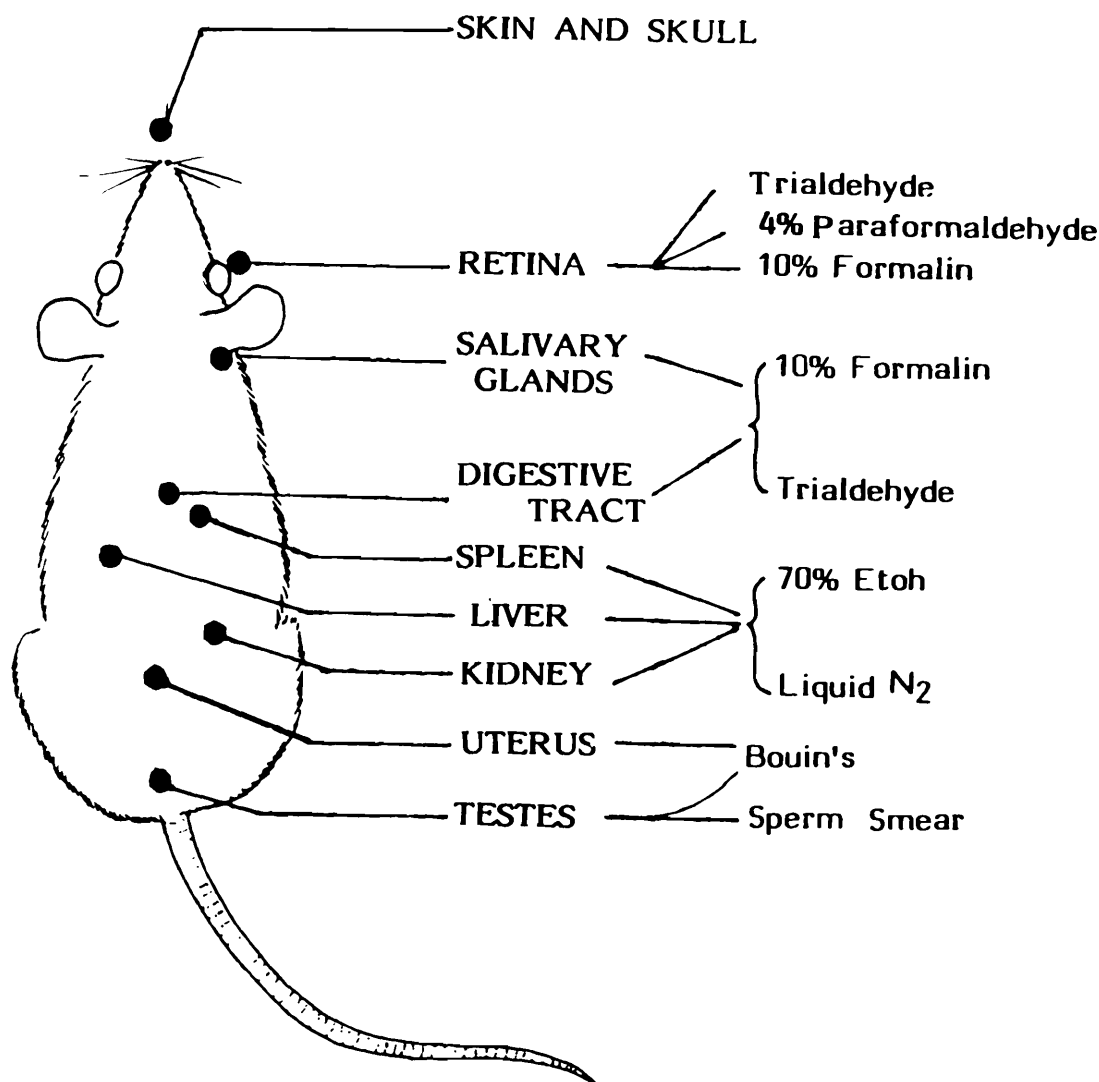


Fig. 1. — A diagrammatic representation of the field protocol used by a field team working in Thailand in 1983. Notice the diversity of data that could be obtained from a single specimen.

rapidly, is Steive's fluid (76 ml saturated aqueous  $\text{HgCl}_2$ ; 20 ml concentrated (40%) formaldehyde; 4 ml glacial acetic acid).

Histochemistry generally presents a special set of problems because general fixation procedures often are unsuitable. For example, formalin-fixed tissues generally are unsuitable for demonstration of lipids or glycogen, whereas alcohol-acetic acid-formalin can be used for glycogen (but not lipids). The trialdehyde fixative described below can be used, together with 10% neutral buffered formalin, for a wide variety of histochemical analyses, particularly those involving complex mucosubstances. Pinkstaff *et al.* (1982) is an excellent source of information about these procedures as applied to a histochemical study of salivary glands.

*Electron Microscopy (TEM)*

Glutaraldehyde has been widely recommended to field collectors who wish to fix tissues for later study with transmission electron microscopy (scanning electron microscopy can be readily accomplished with formalin-fixed specimens and, insofar as field work is concerned, does not require special procedures). Unfortunately, in my experience, glutaraldehyde by itself simply is not an adequate field fixative for quality transmission electron microscopy (Phillips, 1985) and although it is relatively simple to obtain and handle, it is not recommended for potential museum use. The most common problems appear to be (1) osmolarity (causing destruction of certain cellular organelles) and (2) slow penetration. Fortunately, however, there is available a trialdehyde fixative (first described by Kalt and Tandler, 1971) that has proven to be outstanding even under the most rigorous field conditions (Phillips, 1985). This fixative makes possible the routine collection of tissue samples that can be stored for later analysis at the ultrastructural level.

The fixative consists of 1 % glutaraldehyde, 1 % formaldehyde (mixed fresh from paraformaldehyde), 0.5 % acrolein, 2.5 % dimethyl sulfoxide (DMSO) and 1 mM  $\text{CaCl}_2$  in an 0.05 M cacodylate buffer at pH 7.2. To prepare 250 ml (the amount that we prepare each day in the field), one should first dissolve 5 g of paraformaldehyde powder in 25 ml of distilled water (using heat and a few drops of NaOH). Next add 15 ml of 50 % (stock) glutaraldehyde, 6.25 ml of DMSO, 0.25 ml of 0.1 M  $\text{CaCl}_2$  and lastly 2.5 ml of stock acrolein (remember that the acrolein is a dangerous poison and must be handled carefully). Finally, dilute this solution up to 250 ml with a 0.05 M cacodylate buffer with 0.1M sucrose.

In practice, I have found that minced tissues should be left overnight in this trialdehyde fixative; in the morning the fixative is replaced with 0.05 M cacodylate buffer with 0.1 M sucrose. Tissues can be left in buffer, even at tropical ambient temperatures, for at least one month. When refrigeration is available, the tissues should be transferred to 3 % glutaraldehyde and stored at 4°C. The results of this entire procedure are remarkable (Fig. 2) and, thus, data that could be obtained from such a museum collection represent a virtual quantum leap over current practices.

*Immunocytochemistry*

Immunocytochemistry is a procedure by which tissue antigens can be localised and viewed microscopically. In terms of future research involving mammal collections, this technology should be given prime consideration. If antigenicity can be preserved in

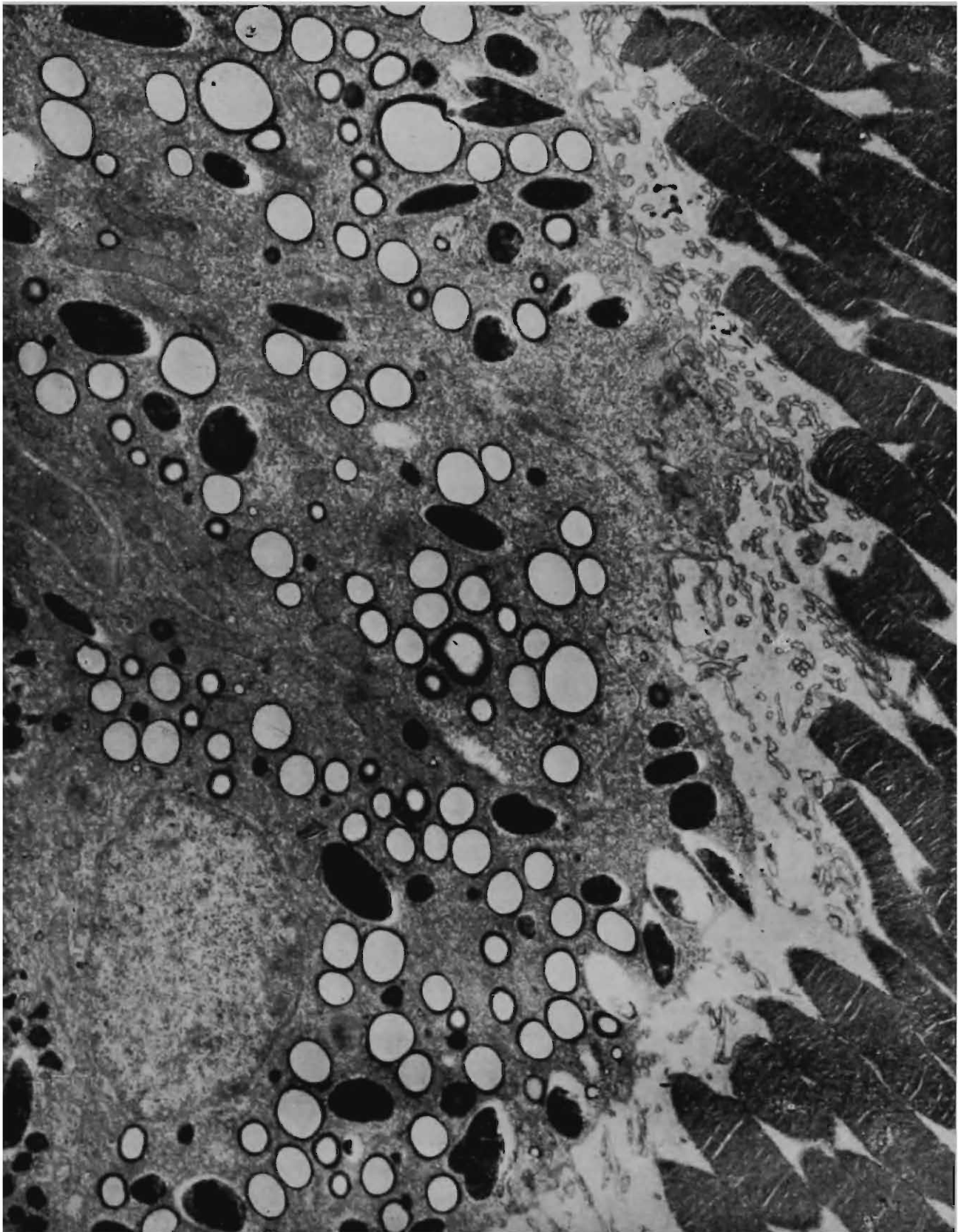


Fig. 2. A transmission electron micrograph of retinal pigment epithelium from a specimen of *Cynopterus sphinx* that was fixed in the field and stored in buffer. Note the extremely good fixation possible with trialdehyde.

tissues, the possibilities then exist that a tremendous range of antigens can be localised as antibodies become available. Currently, immunocytochemistry would allow for such detailed studies as comparisons of

the ganglion layer of the retina and identification and localisation of endocrine cells in the digestive tract. (Studholme *et al.*, 1987; Yamada *et al.*, 1988).

Tissue specimens that have been fixed overnight in 4% paraformaldehyde and then stored in cacodylate buffer and sucrose (just as described above for transmission electron microscopy) later can be used in the laboratory for light level immunocytochemistry. Bouin's fixative also works very well for immunocytochemistry. The only apparent limitation is that for transmission electron microscopy (instead of light-level microscopy), paraformaldehyde fixation is far from perfect and ultrastructural details are lost. Additionally, commonly used ultrastructural fixation techniques are known to hinder the large immunological reagents (150-500 K daltons) and often cause antigens to be non-immunoreactive. Recently, however, Eldred *et al.* (1983) have described a technique that seems to solve this problem and which should be applicable to mammalogical field work. These authors found that electron microscopic localisation of antigens could be accomplished on tissues that were pre-fixed for one hour in 4% paraformaldehyde with 0.1-0.2% gluteraldehyde at pH 7.4 and then fixed for 24 hours in 4% paraformaldehyde at pH 10.4. Next, the tissues were washed for one hour in 0.1 M sodium phosphate buffer at pH 7.4 with 4% sucrose and 0.15 mM  $\text{CaCl}_2$  and, lastly, incubated for 30 minutes in 1% sodium borohydride ( $\text{NaBH}_4$ ).

### DNA

Collection and preservation of tissues suitable for comparative DNA analyses deserves mention because of indications that such techniques are destined to become extremely valuable to systematic research. In both birds and mammals, hybridization of nuclear DNA has been accomplished with tissues (particularly liver and kidneys for mammals) that have been both fixed and stored in 70% ethanol (Sibley and Ahlquist, 1981). Mitochondrial DNA (mt DNA) for comparative populational or interspecific study with restriction enzymes can be extracted from fresh or frozen tissues. Tissues are diced into reasonably small pieces in 10% sucrose and then placed in a cryotube and frozen in the same solution. Such tissues must be thawed slowly (in ice water) to about 4°C in order to limit enzymatic activity.

Insofar as storage is concerned, it appears that tissues can be kept in ethanol for many years. An alternative would be to extract the DNA and then store it in an aqueous form in containers that also contain a small amount of chloroform (Sibley, *per. comm.*). The frozen tissues also can be kept indefinitely by placing them in a -70°C freezer.

## FIELD PROCESSING

General collection of fluid specimens is a routine process easily accomplished under field conditions. But as mentioned previously, this activity all too often has been treated casually so that museums eventually hold collections of mammals that include some percentage of partially decomposed specimens of limited scientific usefulness. As a bare minimum, specimens must be fixed at time of death and, if at all possible, the formalin should be neutral and buffered. It sometimes happens that animals that have been dead for a short time (perhaps as long as 25 minutes) still are worthwhile to fix, at least for studies of gross anatomy or for later removal and cleaning of the skeletons. These specimens always should be clearly labelled so that in the future a scientist wishing to use them will realise how they have been handled. The obvious goal should be to do everything reasonable in the field to maximise the value of each specimen obtained.

In preparing for field work, it is advisable to consider all of the available technical alternatives and then to plan a field processing schedule suited to the needs of the overall project. Obviously, one cannot save all tissues in all types of fixatives on any given occasion. At the same time, however, extensive data can be obtained by integrating a set of technologies. As but one example of an approach to this problem, I have summarised in Figure 1 the types of data that we were able to obtain while doing field work in Thailand in 1983.

We used a group of seven persons (five or six would suffice) as follows to process specimens: (1) one person prepared fixatives each morning, minced tissues for TEM fixation, and replaced fixatives with buffers; (2) one person anaesthetised the specimens, intubated the digestive tract for perfusion with fixatives, removed tissues and made specimen-by-specimen decisions about fixation and procedures; (3) one person removed tissues for eventual DNA analysis and placed them in either ethanol or 10% sucrose and liquid nitrogen; (4) two persons shared the karyotyping responsibilities; and (5) two persons prepared skin and skull specimens and also fixed specimens *in toto* in 10% formalin. The protocol presented in Figure 1 is but a single example of how data collection can be maximised with careful planning. If time permits and the field team remains in one place for several days, different techniques can be employed on different days on a rotating basis.

## STORAGE

Conventionally, mammal specimens fixed with formalin are preserved by storage in ethyl alcohol. A typical procedure would be to

wash specimens overnight in running water to remove the formalin (which tends to continue to harden specimens and which can become acidic) and place the specimens in airtight glass containers filled with 70% ethanol. The containers are stored (usually on metal shelves) in a relatively cool, dark room.

Several aspects of this procedure deserve special consideration. Firstly, although there sometimes is some disagreement about whether or not the formalin should be washed out, most specialists would argue that removal of the formalin is the best course. Aside from producing formic acid, requiring that a buffer be added to the preservative (more time consuming and more expensive), formalin also tends to harden tissues so that light-level microscopic analysis becomes more difficult. Secondly, some collections recently have started to store specimens in isopropyl alcohol instead of ethanol. A mixture of 40-50% isopropanol is said to be preferred by some because: (1) in North America, it usually is less expensive than ethanol; (2) it is less volatile than ethanol, and (3) specimens are possibly softer (more easily manipulated) than those preserved in ethanol. The negative aspects of using isopropanol outweigh, at least in my view, the few advantages listed above. Isopropanol is not suitable for preservation of tissues for histology and that in itself eliminates one broad area of scientific value of the specimen. Isopropanol also is not so easily diluted as is ethyl alcohol; it also is harder to test for true concentration and some collection managers have reported separation of water and isopropyl alcohol.

Tissues intended for future histological use almost always should be preserved in 70% ethanol. Occasionally, some fixatives can be used as a preservation medium, but from a practical viewpoint, it obviously would be easier to manage a tissue collection stored in ethanol instead of a collection stored in a variety of substances. Tissues fixed in trialddehyde for electron microscopy can be stored in buffered 3% glutaraldehyde at 4-5°C. It is important, however, to check the pH of the glutaraldehyde because if it becomes acidic, cell membranes and some cell organelles will be damaged. Regular field fixation and storage of TEM materials as a part of museum mammal collections is so new that no one can predict with certainty how long refrigerated tissues can be kept without significant loss of ultrastructural detail. Our experience so far suggests that tissues can be stored up to ten years. An alternative to storage in glutaraldehyde would be to at least partially process the tissues and then to store them following their embedment in plastic. These small plastic blocks can be stored with very little shelf space and do not require any special maintenance.

Most often, whole specimens of mammals are stored in glass screw-top jars. A surprisingly large variety of such containers are available



but relatively few are really well-suited to museum use. Ideally, these containers have no neck constriction; the closure (lid) will have a well-matched thread system and an evaporation-resistant liner as well. Construction of containers is very important because a variety of common problems can plague collection managers under the best of circumstances and if the containers are inadequate, the problems are multiplied.

Specimens stored in fluid must be checked on a routine basis. Unfortunately, in a typical collection, the alcohol preservative will evaporate at different rates from different individual containers, depending upon tightness of the seal and the degree of "backing-off" of the lid. Several management schemes are possible. One approach is to routinely empty the contents of containers (a few at a time) through a sieve into a large container. Fresh 99% alcohol is then added to the old, filtered alcohol and an alcohol hydrometer is used to adjust the solution to 70%. The process is conservative and insures that fresh, clear alcohol of the appropriate concentration always will bathe the specimens. In some collections, the managers prefer to keep all containers filled to the top so that evaporation will be recognised immediately. The only disadvantage to this approach is that it requires more alcohol because not infrequently a given container will be only partially filled with specimens.

#### SUMMARY

This report describes a variety of currently available field preparation techniques and storage procedures for tissue specimens from mammals. Both of these topics must be given increased attention if we are to be successful in maximising data and preserving specimens for study by future generations of scientists. In world-wide museum mammal collections the traditional approach has been to fix specimens in "10%" formalin and then to store them in a mixture of 70% ethyl alcohol (or, sometimes in formalin itself). Although this technique is not without pitfalls, it nevertheless remains as the best, simplest, and most generally useful field procedure for fixation and storage. At the same time, however, there now are available alternative or supplemental techniques that are nearly as easy to employ and which can provide us (and future generations) with additional, more technically advanced kinds of data. It recently has become possible to fix tissues in the field for transmission electron microscopy. A relatively simple trialdehyde-DMSO fixative (1% glutaraldehyde, 1% formaldehyde, 0.5% acrolein, and 2.5% dimethyl sulfoxide) has proven in recent years to be remarkably effective, even without refrigeration in tropical environments. Immunocytochemistry now can be initiated in the field when specimens of mammals are collected. Tissues need only be fixed in 4% paraformaldehyde or Bouin's fluid to be suitable for this type of research.

Tissues suitable for DNA-DNA hybridization can be both fixed and stored in 70% ethanol. With advanced planning, a field team can divide mammal tissues into lots and employ a wide variety of fixations (Fig. 1). The scientific value of the museum collection thus is greatly magnified. Although future collections undoubtedly will include the traditional containers of whole specimens stored in alcohol or formalin, it also is possible to envision collections that will include slides, tissue samples, and even micrographs as part of the data base.

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#### REFERENCES

- BROWN, J. C. 1979. Techniques in mammalogy, Ch. 9. Microscopical examination: histochemical methods. *Mammal Rev.*, 9(3): 96-141
- BROWN, J. C. and HILTON, A. J. 1979. Techniques in mammalogy, Ch. 8. Microscopical examination: histological technique. *Mammal Rev.*, 9(2) : 53-95.
- BROWN, J. C., and STODDART, D. M. 1977. Techniques in mammalogy Ch. 7. Killing mammals and general post-mortem methods. *Mammal Rev.*, 7(2) : 64-94.
- CHAYEN, J., BITENSKY, L. and BUTCHER, R. G. 1973. *Practical histochemistry* : xiii+271, Wiley, New York.
- CULLING, C. F. A. 1974. *Handbook of histopathological and histochemical techniques (including museum techniques)* : xiv+712, Butterworths, London.
- ELDRED, W. D., ZUCKER, C., KARTEN, H. J. and YAZULLA, S. 1983. Comparison of fixation and penetration enhancement techniques for use in ultrastructural immunocytochemistry. *J. Histochem. Cytochem.*, 31 : 285-292.
- FORMAN, G. L. 1971. Histochemical differences in gastric mucus of bats. *J. Mammal.*, 52 : 191-193.
- FORMAN, G. L. 1972. Comparative morphological and histochemical studies of selected American bats. *Univ. Kans. Sci. Bull.*, 59 : 591-729.

- FORMAN, G. L. PHILLIPS, C. J. 1988. Preparation and fixation of tissues for histological, histochemical, immunohistochemical, and electron microscopic studies. *Ecological and Behavioral Methods for the Study of Bats* : 405-424. T. H. Kunz (ed.), Smithsonian Inst. Press, Washington, D. C.
- GOPALAKRISHNA, A. and MURTHY, K. V. R. 1960. Utero-ovarian junction in two species of bats. *Bull. zool. Soc., Coll. of Sci., Nagpur*, **3** : 19-22.
- GRAY, P. 1964. *Handbook of basic microtechnique* (3rd ed.) : xii+302, McGraw-Hill, New York.
- GRAY, P. (ED.). 1973. *The encyclopedia of microscopy and microtechnique* (3rd ed.) : xi+638, Van Nostrand Reinhold Co., New York.
- HOOD, C. S. and SMITH, J. D. 1983. Histomorphology of the female reproductive tract in phyllostomatoid bats. *Occ. Pap. Mus., Texas Tech Univ.*, **86** : 1-38.
- HOOD, C. S. and SMITH, J. D. 1982. Cladistical analysis of female reproductive histomorphology in phyllostomatoid bats. *Syst. zool.*, **3** : 241-251.
- HUMASON, G. L. 1979. *Animal tissue techniques* : xii+661, W. H. Freeman and Co., San Francisco.
- KALT, M. R. and TANDLER, B. 1971. A Study of fixation of early amphibian embryos for electron microscopy. *J. Ultrastruct. Res.*, **36** : 633-645.
- KARIM, K. B. 1975. Tubo-uterine junction in two species of Indian bats. *Curr. Sci.*, **44** : 589-590.
- KIERNAN, J. A. 1981. *Histological and histochemical methods : theory and practice* : xii+344, Pergamon Press, Oxford.
- LILLIE, R. D. and FULLMER, H. M. 1976. *Histopathologic technic and practical histochemistry* (4th ed.) : xvii+942, McGraw-Hill, New York.
- PHILLIPS, C. J. 1985. Field fixation and storage of museum tissue collections suitable for electron microscopy. *Acta zool. Fennica*, **170** : 87-90.
- \*PHILLIPS, C. J. and STUDHOLME, K. M. 1982. Comparative ultrastructure of gastric chief cells in carnivorous and frugivorous bats. *IRCS Med. Sci., Cell Membrane Biol.*, **10** : 573-574.

- PHILLIPS, C. J., STUDHOLME, K. M. and FORMAN, G. L. 1984. Results of the Alcoa Foundation Suriname Expeditions. VIII. Comparative ultrastructure of gastric mucosae in four genera of bats (Mammalia: Chiroptera) with comments on gastric evolution. *Ann. Carnegie Mus.*, **53** : 71-117
- PINKSTAFF, C. A., TANDLER, B. and COHAN, R. P. 1982. Histology and histochemistry of the parotid and the principal and accessory submandibular glands of the little brown bat. *J. Morph.*, **172** : 271-285.
- QUAY, W. B. 1968. The specialized posterolateral sebaceous glandular regions in microtine rodents. *J. Mammal.*, **49** : 427-445.
- QUAY, W. B. 1974. Bird and mammal specimens in fluid —objectives and methods. *Curator*, **17** : 91-104.
- SIBLEY, C. G. and AHLQUIST, J. E. 1981. The phylogeny and relationships of the ratite birds as indicated by DNA-DNA hybridization. *Evolution Today* : 301-335. G.G.E. Scudder and J.L. Reveal (eds.), *Proc. Internat. Cong. Syst. Evol. Biol.*
- SOKOLOV, V. E. and DZHEMUKHADZE, N. K. 1982. Enzyme histochemistry in specific cutaneous glands of *Erinaceus europaeus* during hibernation. *Dokl. Akad. Nauk SSR*, **264**(6) : 1492-1494 (English translation).
- STUDHOLME, K. M., YAZULLA, S. and PHILLIPS, C. J. 1987. Interspecific comparisons of immunohistochemical localization of retinal neurotransmitters in four species of bats. *Brain, Behavior, and Evolution*, **30** : 160-173.
- SWARUP, B., KUMAR, D. and SINHA, B. N. 1971. The histological structure of stomach in bat (*Rhinopoma kinneari*). *Indian J. Med. Res.*, **59** : 259-264.
- TANDLER, B., NAGATO, T. and PHILLIPS, C. J. 1983. Ultrastructure of the submandibular gland in four species of fruit bats (*Artibeus* sp.). *Anat. Rec.*, **205** : 198A.
- YAMADA, J., LI, B., DENG, Z., KITAMURA, N., YAMASHITA, T. and PHILLIPS, C. J. 1988. An immunohistochemical study of gut endocrine cells in two species of insectivorous vespertilionid bats (Chiroptera: *Pipistrellus abramus* and *Plecotus auritus*). *Gegenb. morph. Jahrb.*, **134** : 79-91.

## DISCUSSION

- Q. What system of cataloguing do you use for your collection of histological slides ?*
- A. All slides, micrographs, or other such material (i.e. tissues) are labelled with the field collection number assigned from the CJP catalogue. This number would lead the researcher to either catalogue or computerise data, which have additional information including the deposition of the voucher, sex, locality, fixation, etc.
- Q. What fixatives and storage system in the field would you suggest for blood collection for protein-taxonomy ?*
- A. Isozyme analyses can be done with materials that have been frozen in liquid N<sub>2</sub> or dry ice. Cryoprotection with 10 % sucrose should be considered. DNA-hybridization can be done with tissues fixed in 70 % ETOH or frozen Mitochondrial DNA can be isolated from fresh or frozen tissue.
- Q. What is neutral, buffered formalin ?*
- A. 100 c.c. of 40 % formalin, 900 c.c. of water, 4 gm acid sodium phosphate (monohydrate), and 6.5 g. anhydrous disodium phosphate (pH 7.0).
- Q. Will it be possible to use glycerine along with preservative-fluid for small mammals ?*
- A. Yes, such a technique is possible but in my mind 70 % ethyl alcohol is the best.
- Q. Do you have any idea about effects of formalin on keratin or fogging and discolouring of mammalian skin ?*
- A. Formalin fixes keratin very well in so far as histology is concerned. In my experience formalin clearly affects the colour of hair. This is probably due to formic acid present in commercial formalin which acts as an oxidizing agent.
- Q. Can you comment on the best storage medium for fluid-preserved specimens once they are back in the Museum-collection ?*
- A. Formalin fixed specimens should be washed in water and stored in 70 % ethyl alcohol. Other media, though available, render the specimens useless for histological studies.
- Q. Do you find osmic acid useful for fixation of tissue for electron-microscopy ? Are there chemicals to preserve colour of biological specimens ?*
- A. Osmic acid can be used for transmission electron microscopy. However, in certain special cases it is not the fixative of choice. A trialdehyde mixture (glutaraldehyde, acrolein, paraformaldehyde) in a buffer with DMSO is the best. I don't know how to preserve colour in a fluid-preserved specimen but I would assume that pH is extremely important.

## **PREPARATION AND STORAGE OF FLUID-PRESERVED SPECIMENS**

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### **INTRODUCTION**

The collection and preservation of animals for scientific study is both an art and a science. By long experience in many parts of the world, proper methods for the collection and preservation of various groups of animals have been evolved.

The main purpose of making Zoological collections is that properly documented specimens in good condition should be readily available for study/reference, whenever required. The value and utility of Zoological collections for scientific research and education lie in the better and efficient management of the collection.

A great variety of mammals occur in the tropics. The Recent mammal collections in the tropics are continuously growing in size and in number, and are a valuable resource for many disciplines, particularly those affiliated with education, systematics, environmental studies, wild-life biology and parasitology. With the growth and development of Recent mammal collections, numerous ideas concerning collection management have been conceived. Some aspects, such as preparation and storage of fluid-preserved specimens of mammals are important areas for proper management.

In a limited scope of this paper the methods of preparation and storage of fluid-preserved specimens of mammals, which are followed in a tropical zoological institution like the Zoological Survey of India, Calcutta, have been discussed. These have been compared with the methods that are followed in some modern museums of U.S.A.

### **FLUID-PRESERVED MAMMALIAN SPECIMENS**

The fluid-preserved specimens of mammals are generally small mammals, particularly insectivores, chiropterans, and rodents. Sometimes small carnivores and lagomorphs are also preserved wet.

### *Procedures*

The format of the procedures that are followed with the wet specimens of mammals in the Zoological Survey of India are as follows :

After accessioning

Sorting

Washing

Semidrying

Change of label, if necessary

Temporary storage for identification

Extraction & cleaning of skull

Identification

Registration & labelling

Permanent storage and arrangement

### **SORTING AND WASHING**

After accessioning an acquisition in a register known as "Acquisition Register", the wet collection of mammals are sorted out into respective groups as rats, mice, bats, shrews, etc., in enamelled trays (Fig. 1) with the help of a pair of forceps. Then they are washed in running tap water for 15-20 minutes with a view to remove fixative (formaldehyde or ethyl alcohol) so that the specimens may be transferred to a permanent preservative (90% ethyl alcohol or 4% formaldehyde solution).

### **SEMIDRYING AND CHANGE OF LABEL**

After washing, the specimens are semidried in the open air by keeping the trays in slanting position to facilitate draining of water from them. Finally, the specimens are wrapped in dry absorbent cotton to soak the residual external moisture, if any (Fig. 2). The time for semidrying varies from 6-18 hours depending upon the nature of pelage and size of the specimen. If during the above mentioned process any field label is torn, it is changed with a substitute label, after copying the data from the original label.



Fig. 1—Sorting of specimens into respective groups.



Fig. 2—Semidrying of the specimens.

#### TEMPORARY STORAGE

##### *Jar types and sizes*

Specimens are now ready to be put into the glass jars. They are kept in the glass jars, matching with the size of the specimens. The glass jars



should be slightly bigger than the specimens. At present, 12 different sizes of glass jars are available. Among these, six are "Sigcal" (A & B) type with glass lid, three are "Yera" type with polythene lid and the remainder are bakelite-lid type jars. "Sigcal" A1 type is the largest, having its height 30 cm, bottom diameter 15 cm, diameter of the open mouth 11 cm and circumference 47 cm ; then comes "Sigcal" A2, after that 'Yera' type I and then bakelite-lid type I and the smallest is the bakelite-lid type III, having its height 10 cm, bottom diameter 5.25 cm, diameter of open mouth 4.75 cm and the circumference 17 cm. Among these jars, bakelite-lid type is unsuitable for keeping wet collection because the lid easily cracks during handling.

The most commonly used glass jars in the museums of U.S.A. (Palmer, 1974) for keeping wet collections is the wide-mouth variety, with a bakelite or polythene lid.

#### *Jar label*

A label is written with a soft pencil on a good, strong, durable paper and kept in the jar for easy recognition of specimens in it. The data on the label includes the name of the survey, number of specimens (e.g. 11 rats or bats), locality, date of collection, name of the collector, etc. The label is placed in such a manner that it is visible from out side of the jar. The size of the label depends on the size of the jar.

#### *Preservative*

Ethyl alcohol (approx. 70%) is used as preservative of the specimens. After putting the specimens in the jar, sufficient amount of preservative is filled in it to prevent desiccation. The level of preservative is always kept higher than the specimens in the jar. Although we use ethyl alcohol (90%) as preservative, its strength comes down to 70% after coming in contact with moisture present within the specimens and the atmospheric humidity.

70% ethyl alcohol, 45% isopropyl alcohol or occasionally 10% buffered formalin (Anderson, 1965) are used as permanent preservatives in different museums in U.S.A. Isopropyl alcohol is more popular in U.S.A. as it is cheap, safe to use and does not need tax clearance.

#### *Size of steel racks and cubicle*

Now the jars are ready to be stacked temporarily on steel racks. These are arranged typologically. Each of the steel rack measures 250 cm in height, 92 cm in width, and 61 cm in depth with five adjustable shelves. Since steel racks are open on three sides, there is more of dust accumulation on the jars, which needs frequent cleaning.

The Royal Ontario Museum uses “light-proof” curtains to shield specimens located on metal shelving (Williams, Laubach and Genoways, 1977). As the alcoholic specimens are particularly sensitive to sunlight it is stored in the Zoological Survey of India in dark places. To prevent colour changes, the use of butyl hydroxytoluene in formalin solution has been suggested (White and Peters, 1969).

#### EXTRACTION AND CLEANING OF SKULLS

Extraction and cleaning of skulls are essential, prior to authentic identification. For extraction of skull, a slight incision is given on both sides of the mouth, and with the help of a scalpel and a stout needle the skin is gradually loosened from the skull-muscles. After removing the skull, cotton is inserted in the head-skin of the specimen to simulate the original size and shape of the head. A few carefully placed stitches are given on the lips to prevent subsequent tearing of the head. After extraction of skull a tag is tied to it, bearing the collection number, locality and date of collection of the specimen.

For cleaning, the skulls are boiled for 45-90 minutes (Fig. 3) depending on their size. Then the muscles are cleaned with the help of a pair of forceps. The brain is scooped out through the foramen magnum by a bent needle.



Fig. 3—Boiling of skulls for cleaning.

The cleaned skulls with proper labels (Fig. 4) are put into separate skull bags (Fig. 5) according to the size of the skulls, and the bags tied

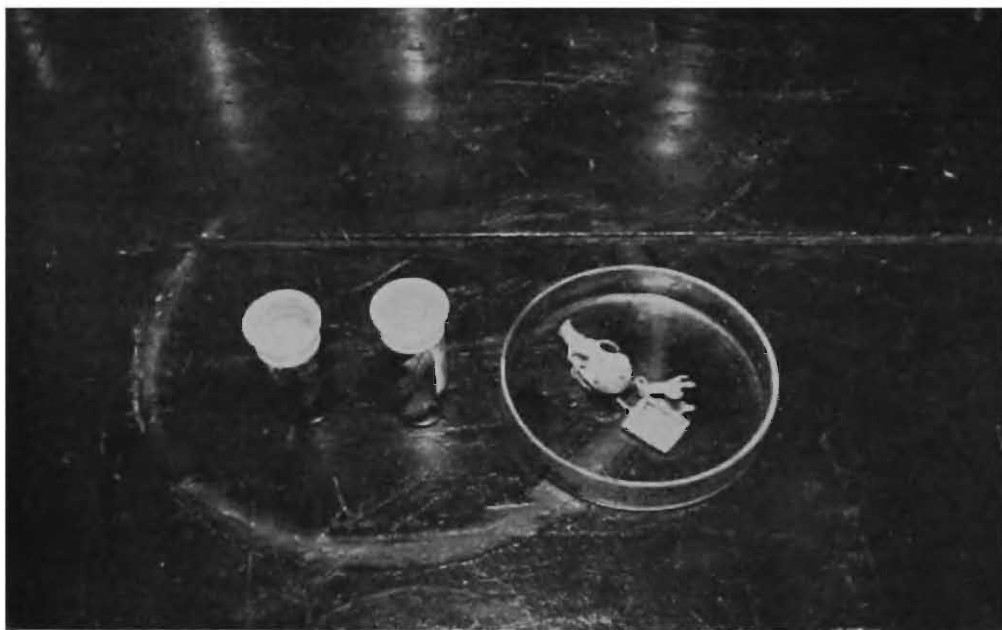


Fig. 4--Cleaned skull with label and glass tubes for delicate skulls.

with the hind legs of the respective specimen. If the skulls are delicate as for example of mice or microchiropteran, they are kept into glass tubes (Figs. 4 & 5) with proper labels and put into the same glass jar in which the specimens are stored.

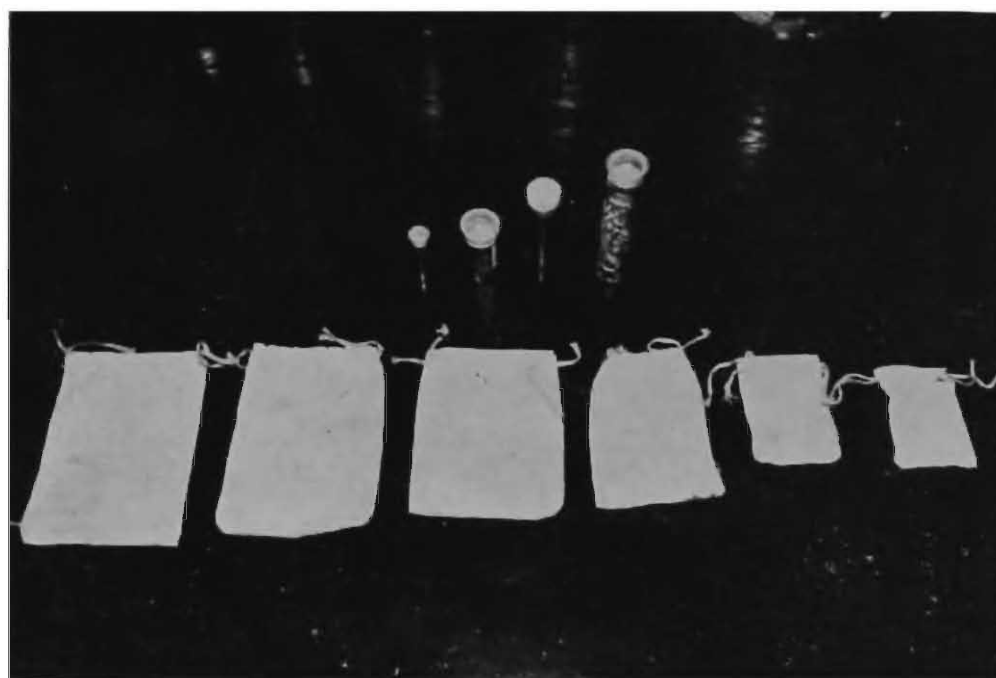


Fig. 5- -Different sizes of skull-bags and glass tubes for storing skulls.

In museums of U.S.A., the skeletal materials are cleaned by the use of larvae of dermestid beetles (Grady, 1928 ; Borell, 1938 , Hall



Fig. 6—Jars with permanent labels for storing.

and Russell, 1933 ; Heal, 1942 ; Peterson, 1964 ; Russell, 1947 , Roth and Willis, 1950 ; Hooper, 1956 ; Laurie and Hill, 1951 Hildebrand, 1968 ; Sommer and Anderson, 1974 ; Tiemeier, 1940). This is a very good method and has the advantage of cleaning very small and delicate skulls without any damage to it. But on the other hand it is a potential threat to mammalian collections because of the damage they can do to prepared skins especially in tropical environment. For this reason dermestid colony should be maintained isolated from the main collection (Gennaro and Salb, 1972 , Hall and Russel, 1933 Vorhies, 1948) preferably in another building. However, in the Zoological Survey of India due to lack of space, the facility for maintaining a colony of dermestid beetles for cleaning of skeletal material is not available.

#### IDENTIFICATION

After skull cleaning, the specimens are ready for identification. Identification is generally done by specialists to subspecific level. The name of the taxon is written with a soft pencil on the field label or on a substitute label.

#### REGISTRATION AND LABELLING

After registration (which will be dealt in detail in another article), a printed label of the Institute, bearing the registration number, name of taxon, locality, date of collection, name of collector, etc., is tied with

the specimen. The data on the label is written in waterproof black ink. The extracted skull from the specimen is also marked with the same registration number

#### PERMANENT STORAGE AND ARRANGEMENT

The temporary jar-label is replaced by a permanent label made up of "Skolar" brand cartridge paper. The name of the taxon, sex, registration number of each specimen, locality, collector, date of collection, etc., are written over it in waterproof Indian Ink (Fig. 6). After that the jars are placed on the steel racks (Fig 7). The jars are arranged phylogenetically up to genus, following the classification given by Ellerman and Morrison-Scott (1951), and then the species and subspecies are arranged alphabetically. Embryological and anatomical materials are stored separately, wherever available, with suitable registration number



Fig. 7--Jars arranged on the steel racks.

The fluid-preserved type specimens are kept separately from the general collection and stored in steel almirahs for their safety and security. They are also arranged in the same manner as the general collection (Fig. 8).

Storage vessels should be filled as close to the brim as possible to make any subsequent loss of fluid more readily discernable. Dessication problems can be virtually eliminated by the use of good quality storage



Fig. 8—Fluid-preserved type specimens in steel almirah.

vessels and periodic inspection. Specimens should not be crowded into the vessels. Usually the volume of preservative should be twice the volume of the specimens (Zweifel, 1966).

At the National Museum of Natural History (USNM), Washington, D.C., jars are arranged on shelves according to size and not according to taxon (Williams, Laubach and Genoways, 1977), instead, a phylogenetic cardfile giving the location of each specimen is maintained. Advantages of this system is the better utilisation of space. However retrieval of specimens belonging to any given taxon is rather time-consuming.

Some collections (for example, Royal Ontario Museum, and Texas Cooperative Wildlife Collection, Texas) store the original published description with their holotype specimens. The Department of Mammalogy at The Royal Ontario Museum follows rather extensive documenting procedure with its type holdings (Williams, Laubach and Genoways, 1977).

## SUMMARY

Fluid-preserved specimens of mammals form a substantial part of the mammal collections in a museum or institution. Preparation and storage of these specimens in an efficient manner is a part of management of collections. The procedures that are followed in an institution like the Zoological Survey of India which is situated in tropical environment, are described, and compared with the methods that are followed in some sophisticated museums of the United States of America.

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## REFERENCES

- ANDERSON, R. M. 1965. Methods of collecting and preserving vertebrate animals. *Bull. natn. Mus. Can.*, **69** : 1-199.
- BORELL, A. E. 1938. Cleaning small collections of skulls and skeletons with dermestid beetles. *J. Mammal.*, **19** : 102-103.
- ELLERMAN, J. R. and MORRISON-SCOTT, T C. S. 1951. *Checklist of Palaearctic and Indian Mammals*. British Museum (Natural History), London.
- GENNARO, A. L. and SALB, T J. 1972. An outdoor enclosure for dermestid defleshing operations. *Swest. Nat.*, **17** : 95-96.
- GRADY, A. G. 1928. Studies in breeding insects throughout the year for insecticide tests. *J. econ. Ent.*, **21** : 604-608.
- HALL, E. R. and RUSSELL, W C. 1933. Dermestid beetles as an aid in cleaning bones. *J. Mammal.*, **14** : 372-374.
- HEAL, R. E. 1942. Evaluating protection of fabrics from clothes moth and carpet beetle attack. *J. econ. Ent.*, **35** : 249-255.
- HILDEBRAND, M. 1968. *Anatomical preparations*. University of California Press, Berkeley, California, pp. 1-100.

- HOOPER, E. T. 1956. Selection of fats by dermestid beetles, Dermestidae. *J. Mammal.*, **37** : 125-126.
- LAURIE, E. M. O. and HILL, J. E. 1951. Use of dermestid beetles for cleaning mammalian skeletons. *Museums J.*, **51** : 206-207.
- PALMER, W. M. 1974. Inexpensive jars for museum specimens. *Curator*, **17** : 321-324.
- PETERSON, A. 1964. *Entomological techniques*. Edwards Brothers, Inc., Ann Arbor, Michigan.
- ROTH, L. M. and WILLIS, E. R. 1950. The oviposition of *Dermestes ater* Degeer, notes on bionomics under laboratory conditions. *Amer. Midl. Nat.*, **44** : 427-447.
- RUSSELL, W. C. 1947. Biology of the dermestid beetle with reference to skull cleaning. *J. Mammal.*, **28** : 284-287.
- SOMMER, H. G. and ANDERSON, S. 1974. Cleaning skeletons with dermestid beetles-two refinements in the method. *Curator*, **17** : 290-298.
- TIEMEIER, O. W. 1940. The dermestid method of cleaning skeletons. *Univ. Kans. Sci. Bull.*, **26** : 377-383.
- VORHIES, C. T. 1948. A chest for dermestid cleaning for skulls. *J. Mammal.*, **29** : 188-189.
- WHITE, D. A. and PETERS, E. J. 1969. A method of preserving color in aquatic vertebrates and invertebrates. *Turtox News*, **47** : 296-297.
- WILLIAMS, S. L., LAUBACH, R. and GENOWAYS, H. H. 1977. A guide to the management of recent mammal collections. *Spec. publs., Carnegie Mus. nat. Hist.*, **4** : 1-105.
- ZWEIFEL, R. G. 1966. Guidelines for the care of a herpetological collection. *Curator.*, **9** : 24-25.

#### DISCUSSION

- Q. *Have you thought of using black cotton cloth suspended down the front of the collection shelves to keep out light and minimise dust accumulation ?*
- A. Yes, we have thought about the problem and are planning to provide some cover over our open racks.
- Q. *Does boiling damage delicate skulls ?*
- A. Boiling for a longer time definitely damages delicate skulls. Hence, such skulls should not be boiled for more than 45 minutes.





## **STORAGE EQUIPMENT AND SUPPLIES FOR COLLECTIONS OF MAMMALS**

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### **INTRODUCTION**

An integral part of the management of Recent mammal collections is the storage equipment and supplies used in permanently protecting specimens from damage or loss. If the storage equipment utilised in a collection fails to exclude insect pests or allows other types of damage to occur, even a well-curated collection can suffer a significant amount of damage to specimens. Conversely, if the storage equipment and supplies in a collection function as they should, it may be possible for the specimens to last a number of years with little attention from a curator. My objective in this paper is to examine the types of storage equipment and supplies used in Recent mammal collections and to discuss the advantages or disadvantages, if any, of particular equipment or supplies, and to provide names and addresses of some distributors for these materials.

Much of the information included herein is the result of a continuing research interest in collection management that stemmed from work on an earlier paper (Dowler and Genoways, 1976) that dealt with all types of equipment and supplies used in vertebrate collections. The information provided here pertains primarily to mammal collections in the United States and Canada, with limited attention to collections throughout the rest of the world. Information on storage equipment and supplies from collections outside of North America is, in part, from a questionnaire sent to selected mammal collections in South America, Europe, Asia, Africa, and Australia. The questionnaire was designed to ascertain the equipment and supplies used in mammal collections and to identify distributors for these materials. I would like to thank the following people who were kind enough to respond to the questionnaire: I. Aggundey, National Museum of Kenya, Nairobi, Kenya; M. Aimi, Primate Research Institute, Kyoto University, Aichi, Japan; L. Cederholm, Zoological Museum, Lund, Sweden; J. P. Gosse, Institut royal des Sciences naturelles de Belgique, Brussels, Belgium; D. L. Harrison, Zoological Museum, Sevenoaks, Kent,

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England, D. R. Howlett, Powell Cotton Museum, Birchington, Kent England; R. Hutterer, Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn, Federal Republic of Germany; J. Hutton, The National Museum, Bulawayo, Zimbabwe; P. Lups, Naturhistorisches Museum, Bern, Switzerland; F. Petter, Museum national d'Histoire Naturelle, Paris, France; T. Shariv, Zoological Museum, Tel-Aviv University, Tel-Aviv, Israel; F. Spitzenberger, Natural History Museum, Vienna, Austria; O. Sterba, Institute of Vertebrate Zoology, Brno, Czechoslovakia; P. Swanepoel, Kaffrarian Museum, King William's Town, Republic of South Africa.

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### *Storage Equipment*

Most specimens in Recent mammal collections are small to medium-sized study skins with associated skeletal material (usually skin and skull preparations). For this reason, specimen cases or cabinets are perhaps the single most important pieces of storage equipment in mammal collections. Museum specimen cases in general should protect the specimens from light, dust, insect pests, and severe humidity fluctuations, while allowing easy access, safety in fumigation procedures, and providing an efficient use of space (Williams *et al.*, 1977). These objectives can be met with cases that are essentially air-tight and light-tight.

Specimen cases may be constructed of wood, metal (usually steel), or both. Most European and African collections surveyed are currently using wood cases, however, some either have all metal cases (Natural History Museum of Vienna), cases constructed of metal and wood (Zoologisches Forschungsinstitut und Museum Alexander Koenig), or have more than one type of case construction (Museum national d'Histoire Naturelle; Kaffrarian Museum). There appears to be a trend in North American collections towards the use of all steel cases (e.g. American Museum of Natural History, Carnegie Museum of Natural History, Field Museum of Natural History, among others). Three major manufacturers in the United States provide all steel cases and, although all have standard specimen case designs, all are willing to custom design cases to meet individual collection needs.

There still remain questions as to whether wood or steel is better for specimen case construction. Wagstaffe and Fidler (1968) suggest that steel cases have the advantage of being more fire proof and resistant to insect pests than are wood cases. They mention the only disadvantage

of steel cases might be rare circumstances when condensation might occur on the metal. Wood construction of cases may have a related advantage in that the wood may act as a buffer to rapid fluctuations in humidity that might be detrimental to specimens (S. L. Williams, pers. comm.). Wood may, however, exude vapors that could affect the specimens over time (C. A. Hawks, pers. comm.). More research on the effects of such factors on the permanence of mammal specimens is needed before definitive statements on case design can be made.

Many collections find it necessary to build their own storage cases or have them built by local craftsmen, due to lack of readily available manufacturers or prohibitive costs of such standard cases. Knudsen (1966) provides plans for an all wood specimen case and brief descriptions of case designs are given in Jackson (1926) for those originally used in the U.S. National Museum, and in Wagstaffe and Fidler (1968) for specimen cabinets used in the Liverpool City Museum, England. Plans for an all wood specimen case designed for use in the collection of mammals at the University of Kansas Museum of Natural History, USA, will be provided by the author on request.

Specimen drawers within the cases may be constructed of wood or metal (steel or aluminum). Many collections choose to use drawers of wood construction even in all steel cases because these are often less expensive from manufacturers or can be built in-house at further saving. Drawers of either type are generally uncovered, although some museums (e.g. Zoologisches Forschungsinstitut und Museum Alexander Koenig) use drawers with glass covers.

Case sizes are variable from collection to collection and often within a collection two or more case sizes will be used. In the United States, the most widely used cases are similar in dimensions to those described by Jackson (1926) as 1/4 unit and 1/2 unit cases. The approximate dimensions of these cases are 72 cm (width)  $\times$  100 cm (height)  $\times$  98 cm (depth) and 145 cm  $\times$  100 cm  $\times$  98 cm, respectively. Many collections in North America, Europe, and Africa also use cases of greater height (to 190 cm or more). Cases with a height near 100 cm have the advantage of serving as counter space for work areas in the collection, but can be double stacked where needed to conserve space.

In general, curators selecting specimen cases should consider several design features. Specimen case doors may be a lift-off type or hinged. Some manufacturers have case designs that allow a case door to have both options. Several collections now order cases with recessed handles on the doors that eliminate the possibility of damage that often occurs with handles that are exposed. Cases should be as air-tight as

possible to maximise the effect of any fumigant used, as well as to maintain a relatively constant humidity within the case and to preclude entry of dust or pests. Gaskets of closed cell neoprene, Buna-N polyurethane, or similar materials that contact the door will usually ensure a tight seal. Natural rubber seals have a greater tendency to crack over time. Cases should be painted to protect the metal or wood surfaces. Most collections have white cases to increase reflected light in collection areas, but certain white paints may have the additional advantage of containing pigments that absorb ultraviolet radiation that potentially can damage any exposed specimens in the collection (Hawks, 1988).

Collections that are in areas with high relative humidities may occasionally have problems with the development of mould or mildew. Only three respondents mentioned any problems of this nature, and generally it appears to be rather rare in most collections. Within cases, humidity levels may be controlled to some extent by the addition of trays with a desiccant such as silica gel. One museum case manufacturer in the United States (Steel Fixture Mfg. Co.,) is testing the design of cases (primarily for art objects at this time) that include a tray for desiccant, which may be removed for changing the desiccant without opening the case door (J. A. Dickinson, pers. comm.). Desiccants such as silica gel may be dehydrated and reused indefinitely and thus would not be a continuing expense to the collection.

Another type of equipment now used in some collections of mammals is the compactor. Compactors are mobile storage units of whole banks of cases or cabinets that allows a greater number of cases to be stored in a limited amount of space and yet still be accessed easily. They may be manually moved or motor driven and can be custom designed to meet the needs of a given collection. Mammal collections utilising such systems include those at the Zoological Museum, University of Lund, Lund, Sweden, the American Museum of Natural History, New York City, USA, and the Field Museum of Natural History, Chicago, USA.

Storage of large skulls or skeletons is often a problem for curators. Respondents to the questionnaire utilise a variety of storage methods for large material including open storage on shelves, hanging skulls on wire mesh racks, and storage in large wood or cardboard boxes on shelves. Steel shelving is quite adaptable for this purpose, especially when holdings of large skulls and skeletons are extensive.

Storage of large fluid-preserved specimens is often a problem due to a lack of suitable storage containers for such specimens. For this reason many collections do not usually maintain these types of specimens. The most widely used containers are stainless steel tanks either

purchased from a manufacturer or custom designed and built for a specific collection. A custom made stainless steel tank used in the ichthyological collection of the Museum of Comparative Zoology, Harvard University, Cambridge, MA, USA, is briefly described by Fink *et al.*, (1979). All stainless steel tanks should have gaskets of alcohol resistant materials such as Buna-N synthetic rubber or Neoprene.

Other storage containers used for fluid-preserved specimens include plastic pails of various sizes with tight fitting lids, and custom made epoxy-lined marine plywood boxes. Polyethylene and polypropylene tanks are also available, but Fink *et al.* (1979) report that some types often do not seal well. Bottles and jars for smaller fluid-preserved specimens will be discussed below.

Tanned skins and furs are often stored by hanging them from racks in temperature and humidity controlled rooms, but many collections simply fold skins and store them in specimen cases (Williams *et al.*, 1977). One collection (Zoologisches Forschungsinstitut und Museum Alexander Koenig) stores skins of large mammals by hanging them from racks in large metal cases specially for this purpose. Hawks *et al.* (1984) describe alternative methods of hanging tanned skins (see also Williams, 1988).

Original copies of collection catalogues and irreplaceable documents ideally should be stored in a fireproof safe or file with photocopies available for general use (Van Gelder, 1965). Documents may additionally be protected by storing them within cartons of acid-free paper (Williams *et al.*, 1977). See also Hawks (1988) for further considerations for archival storage.

### *Storage Supplies*

Most collections use dividing trays to hold specimens within specimen case drawers and to help prevent them from shifting in drawers. Trays should be of sizes that fit exactly in the drawer and are modular, i.e. different sized trays may be used to fill drawers in different arrangements. Specifications for paper trays commonly used in mammal collections are given in Appendix A.

Skulls and skeletons of small to medium-sized mammals are usually stored in either vials or boxes, depending on their size. Most collections utilise several sizes of vials for skulls and skeletons of small mammals. Both glass and plastic vials are commonly used. Plastic vials, although more economical, may be susceptible to damage by some fumigants

(Williams *et al.*, 1977), whereas glass vials tend to be resistant to fumigants, but are more expensive and more easily broken. Closures for plastic vials are usually snap-on caps. Closures for glass vials include polyethylene stoppers, plastic screw caps, corks, and metal caps (Fig. 1). Polyethylene stoppers seem to be preferred by most American curators because they provide an effective seal and do not break or become brittle with age, as do corks. Metal caps such as those shown in Fig. 1 are rarely used now, perhaps because of their expense or because

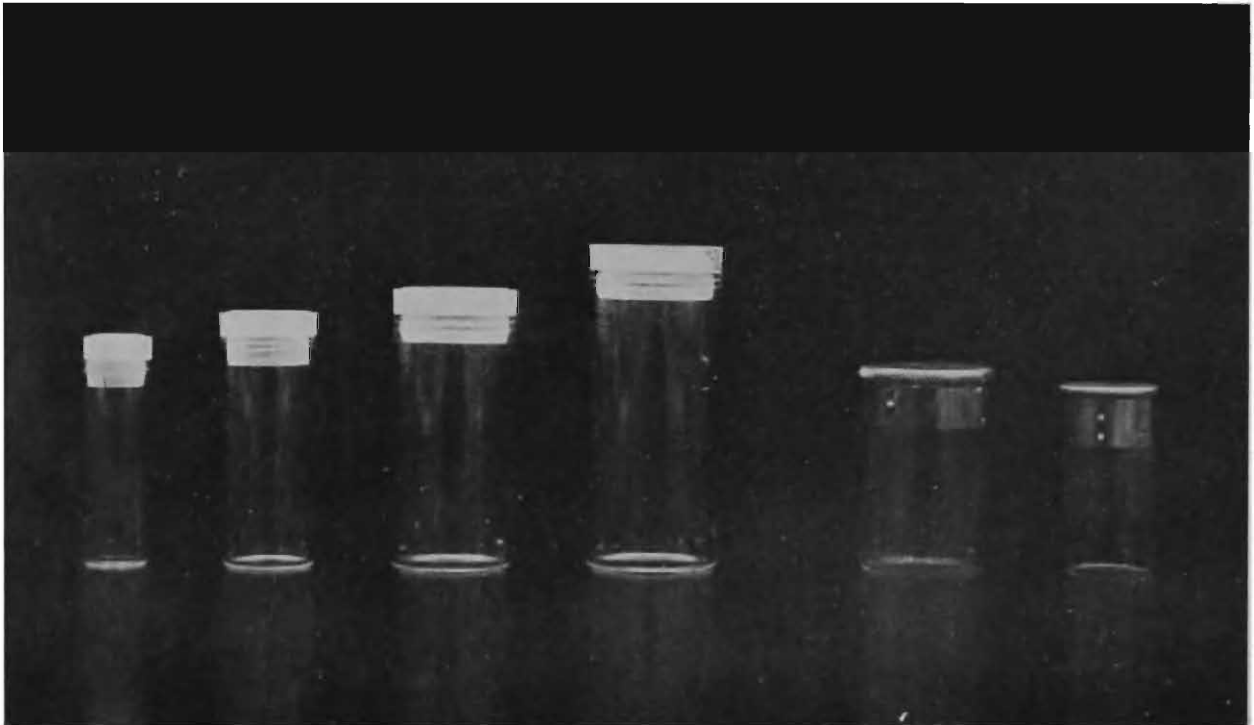


Fig. 1.—Vials used for storage of small mammal skulls and skeletal material. Vials on the left (1, 2, 5, and 7 dram) have polyethylene stoppers and are commonly used in mammal collections. Vials on the right have metal caps and are no longer commonly used.

they are not readily available. They also do not allow level placement of the vials on their sides because of the rim of the cap. Snap caps used on plastic vials and plastic screw caps also share this characteristic. Screw cap vials are also less desirable because they have constricted necks. Most collections utilise three or more vial sizes, with 2, 5, and 7 dram sizes (19 × 48 mm, 27 × 55 mm, and 29 × 65 mm, respectively) being among the most widely used. Gelatin or polyethylene capsules are used for protecting small bacula or individual bones too small to label in these vials or boxes.

Some collections utilise plastic bags rather than vials for storage of small skulls and skeletons, as well as prepared skins. Although zip type plastic bags protect specimens from dust and possible loss of small bones, they do not afford the specimens protection from breakage. One collec-

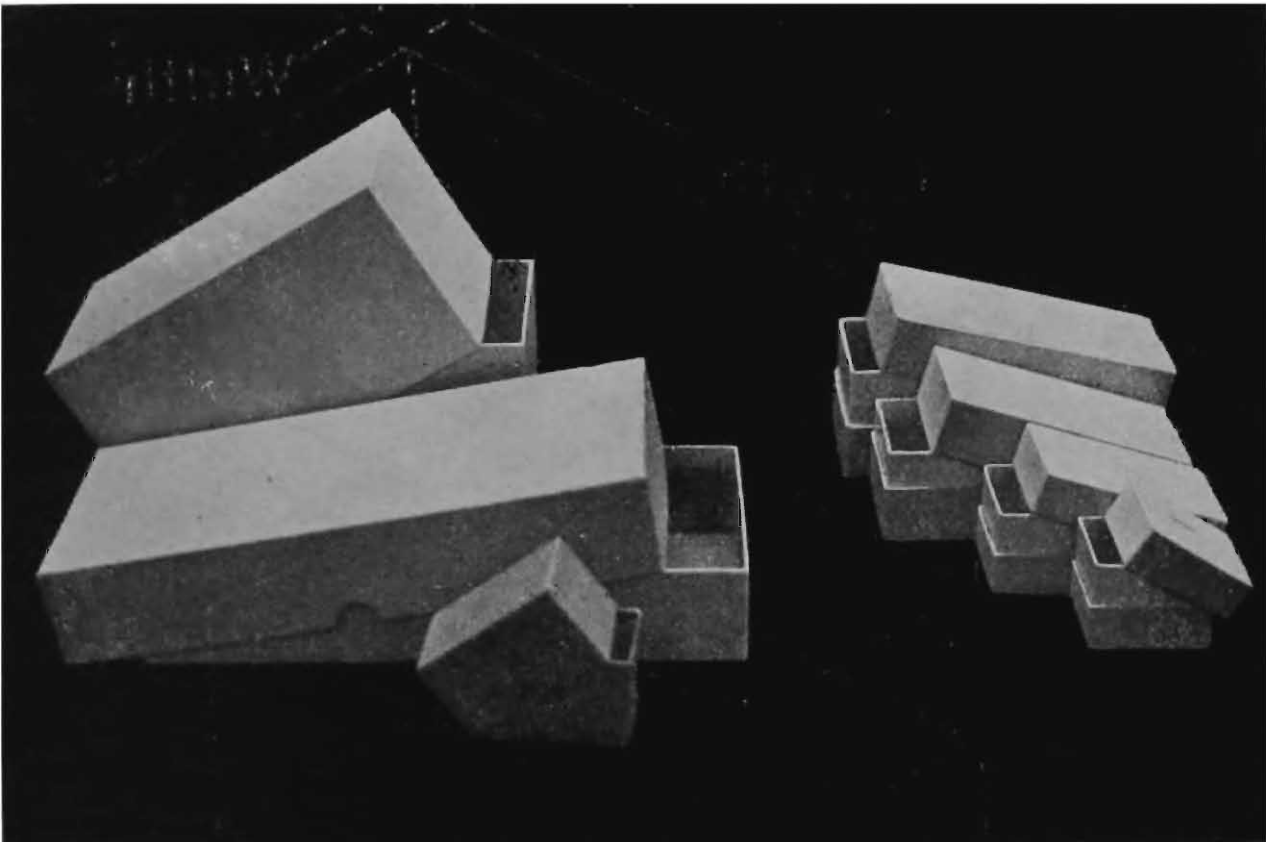


Fig. 2A.—Boxes commonly used for storage of mammalian skeletal material. Boxes on the left are two-piece construction and those on the right are three-piece construction. See appendices A and B for specifications.

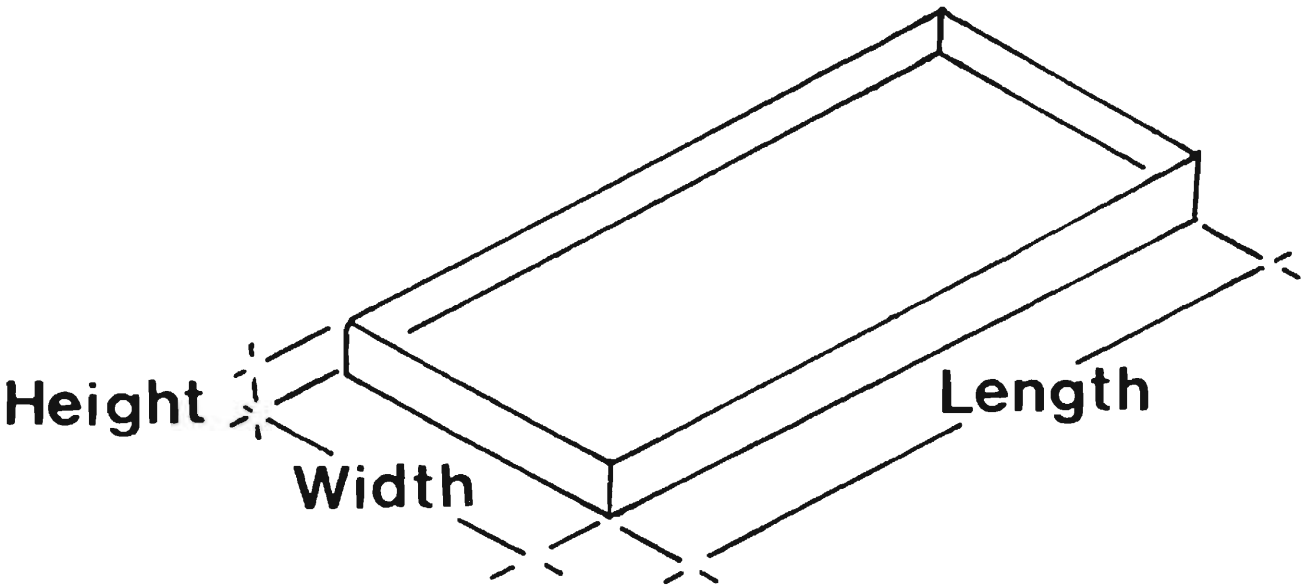


Fig. 2B.—Diagrammatic structure of a one-piece box.



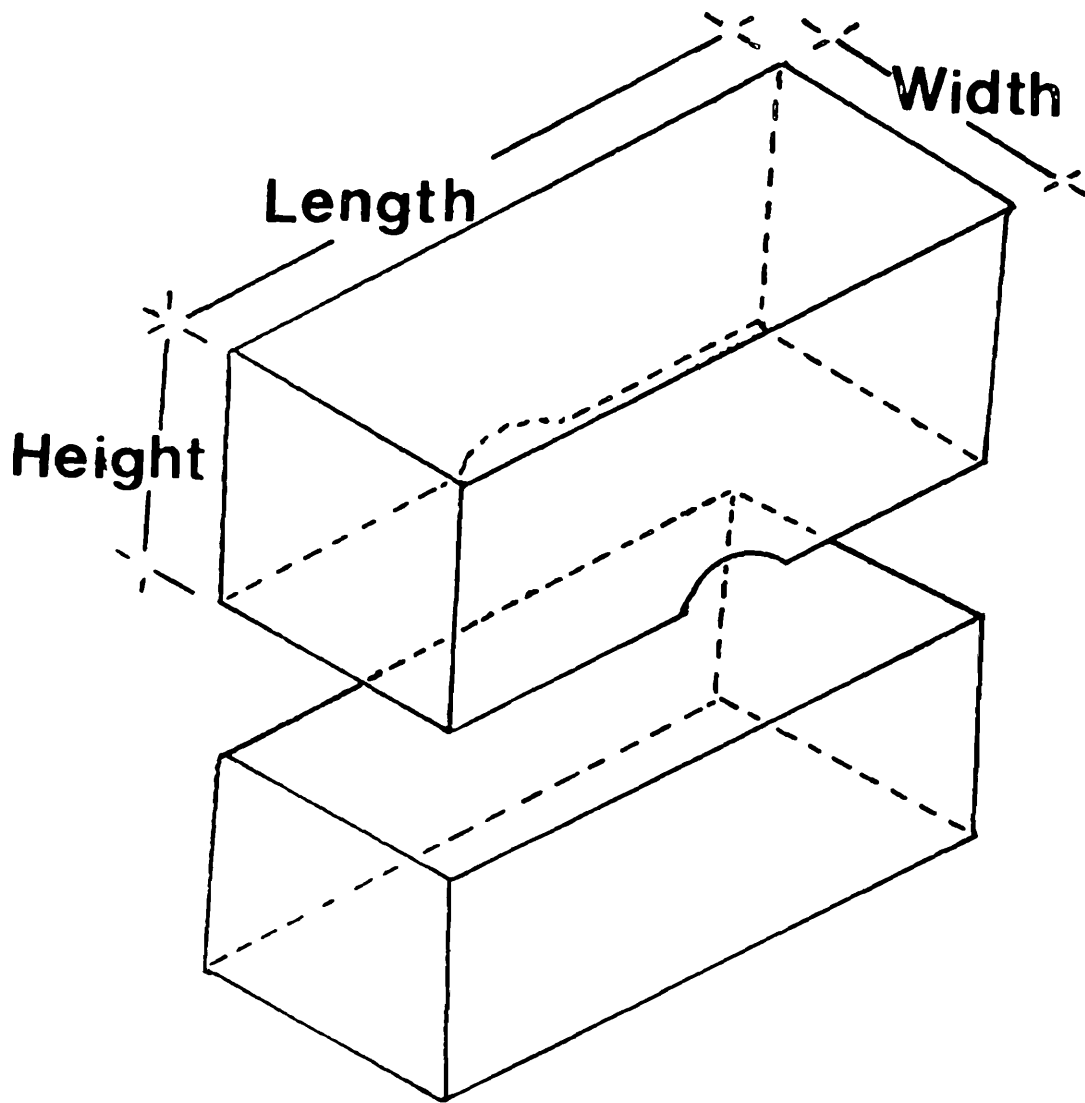


Fig. 2 C.—Diagrammatic structure of a two-piece box.

tion utilising this storage method (the Department of Zoology, University of Lund, Lund, Sweden) compensates for this disadvantage by storing groups of bagged specimens in cardboard boxes.

Boxes of various sizes are usually utilised for skeletal material too large to be placed in vials. Cardboard boxes are generally of two designs (Fig. 2 and Appendix B). The shoulder or three piece box is stronger and preferred by many curators. The two piece box is a less expensive alternative. Specifications for both types of boxes are presented in Appendix B with dimensions of the boxes used in two American collections. Some European collections use plastic boxes rather than cardboard.

A collapsible corrugated cardboard box is used by Carnegie Museum of Natural History, Pittsburgh, PA, USA, for storage of large skulls and skeletons (Williams, 1988). This box measures (in mm) 385 (l) 310 (w) 270 (h), but the height can be reduced by cutting off top portion of the box. Lewis and Redfield (1970) describe the use of fiberglass tote boxes with dust-proof lids for the storage of large skeletal material in anthropological collections.

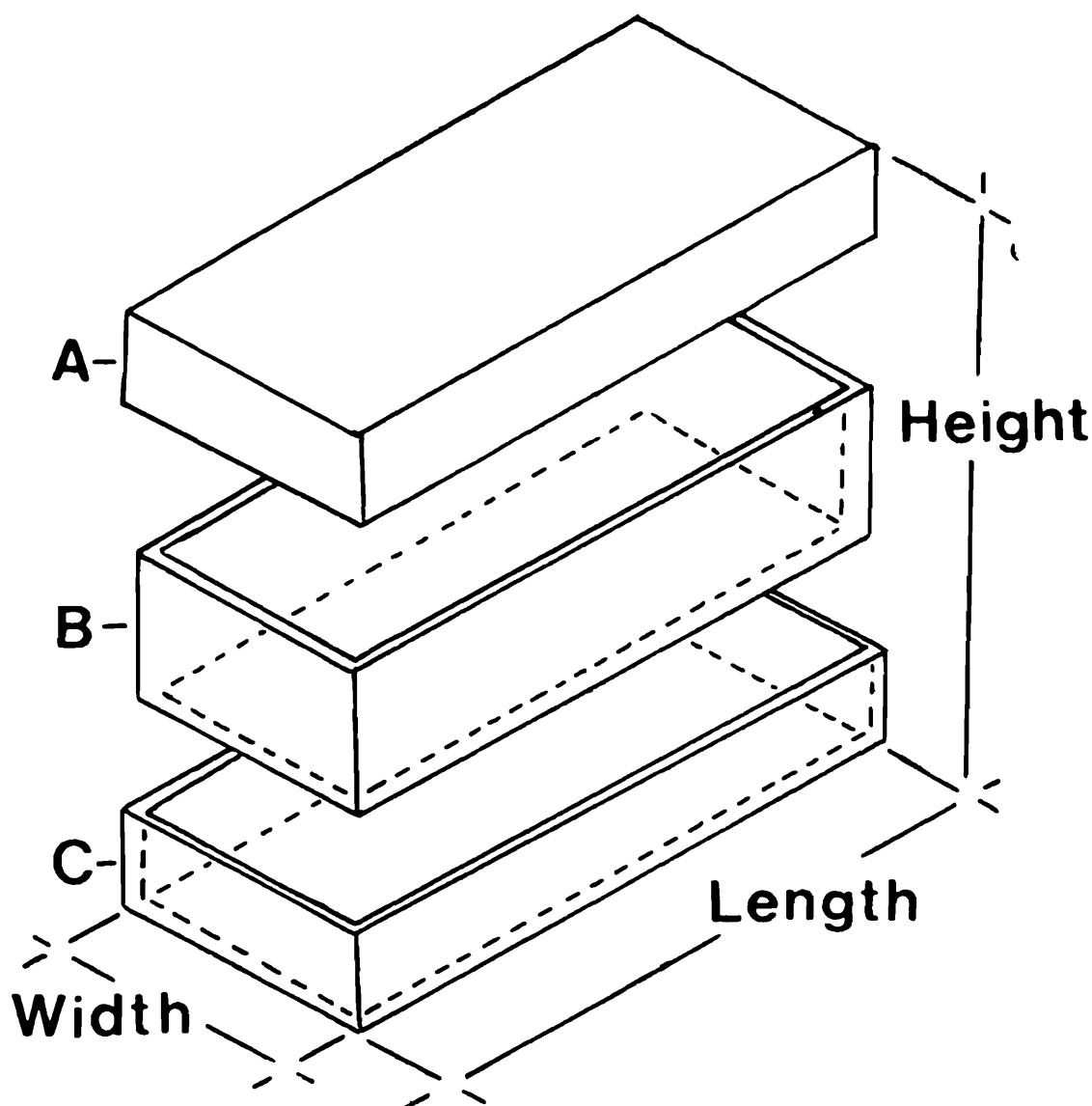


Fig. 2 D.—Diagrammatic structure of a three-piece box.

Fluid preserved specimens are generally stored in jars or bottles, with the exception of large specimens kept in tanks as previously described. A large variety of bottle types and sizes are used in mammal collections. Fink *et al.* (1979) give an excellent review of the types of bottles available for use in museums as well as provide information on the types of closures most effective in preventing evaporation of preservatives.

Three major types of wide mouth specimen jars and closures are used by curators: screw top jars, jars with gasket-type closures and jars with snap-on polyethylene lids. Screw top jars utilise threaded caps of metal, polyethylene, or bakelite (a phenol-formaldehyde polymer). Gasket type jars have glass tops with gaskets and a wire bail that ensures a tight closure. Although many curators prefer jars with gasket type closures, most North American collections utilise screw top jars routinely, due to their greater availability. Jars with snap-on lids are used primarily by some European collections.

The major disadvantage to using jars with screw type closures is the tendency of some screw caps to loosen over time (backing-off), resulting in the evaporation of alcohol. This apparently is caused by differential contraction and expansion of the cap and bottle under variable environmental conditions. Fink *et al.* (1979) report that bakelite or phenolic caps are more subject to backing-off and cracking, than any other closures. Bakelite caps also can crack when initially tightened on jars. The cardboard liners of bakelite caps can partially breakdown when saturated, and further contribute to loosening. Fink *et al.* (1979) reported that curators of ichthyological collections utilising jars with bakelite lids suggested that collections needed to be checked for alcohol loss at least twice a year.

Metal lids have the disadvantage of being susceptible to rust, and consequently allowing evaporation. The use of polyethylene liners can partially solve this problem by forming a better seal than cardboard liners, and by preventing contact of the alcohol with the metal part of the lid. Palmer (1974) reported that standard canning jars with two piece metal lids can be effective specimen jars when the metal liners are replaced by polyethylene disks. The metal screw ring must, however, be wiped thoroughly whenever the jar is opened or closed, to prevent rust, and the metal lids may still rust over several years if stored under humid conditions. The most effective closures for screw-top jars are polypropylene lids with polyethylene liners. These lids will not rust, do not crack when tightened, are less subject to backing-off, and provide a good seal (Fink *et al.*, 1979). It is suggested that lids on jars be retightened one day after initially closing the jars, or just prior to permanent shelving.

Jars with a polypropylene insert type liner are available from Abico Scientific Co., Japan, or the liners may be purchased separately. The liners fit the inner rim of the jar mouth and extend into the jar about 1 cm (Fig. 3). Jars from this company are available in sizes from 70 ml to 8 litres and have been used effectively in ichthyological collections (Fink *et al.*, 1979 ; Hartel, 1980b).

Gasket-type jars are probably the most popular type of jars used in mammal collections. The glass tops are held tightly against a rubber gasket by a wire bail. These jars have the distinct advantage of an automatic tight seal when the bail is in place on the top. There is no need to retighten tops and bail-top jars cannot back-off (Fink *et al.*, 1979). Leakage can occur if the bail is defective, but this can be determined immediately after closing.

The gasket used in bail-top jars has a limited life and ultimately will crack, permitting loss of alcohol. Although resistant to water, the gaskets that come with most jars are less resistant to alcohol and will become brittle and break with time. Replacements should be of a material more

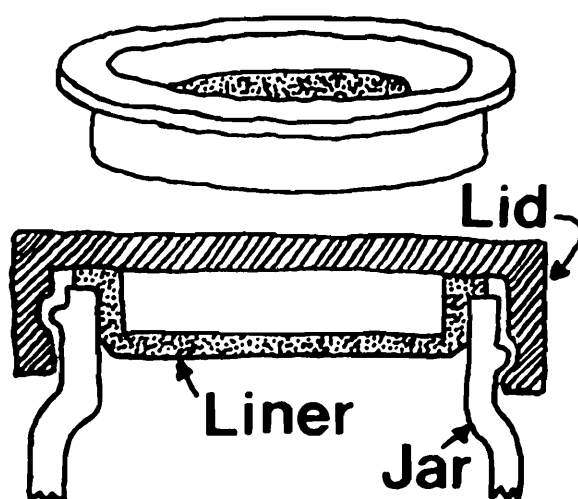


Fig. 3.—Insert type liner for jar closures manufactured by Abico Scientific Company. Liner shown above, with its position in mouth of jar shown below (after Fink, *et al.*, 1979).

resistant to alcohol, such as Buna-N (synthetic nitrite rubber). New gaskets can usually be stamped by local machine cutting companies (Fink *et al.*, 1979). Hartel (1980a) reported that a synthetic rubber, EPDM (brand name Nordel), manufactured by Dupont, is believed to be superior to Buna-N as a material for replacement gaskets.

Production of gasket-type jars in North America appears to be limited to small jars of a single size (254 ml, 8 ounces) by only two companies. For that reason, collections using gasket type jars must purchase jars imported from Europe, primarily from France (brand name Le Parfait and Triomphe) or Italy (brand name Vasi Ermetici Fido). Imported jars are available in sizes ranging from 0.5 litre to 5 litres. The Vasi Ermetici Fido jars are square in sizes under 4 litres, which may allow them to be stored on shelves more efficiently (Fink *et al.* 1979).

Another type of jar used in European collections has a wide mouth and a plastic snap-on closure. These glass jars are manufactured in Denmark, but several museums in other countries use this type of jar (e.g. Zoological Museum, University of Lund, Lund, Sweden). They are available in several sizes from 70 ml to 3 litres. If the polyethylene lids seal well, these jars might present a good solution to problems with other jar designs including backing off of screw lids, rusting of metal lids, and replacement of worn gaskets. No North American collections, to my knowledge, are currently using this type of jar.

## CONCLUSIONS

The storage equipment and supplies, as well as curatorial supplies in general, used in collections of mammals are obviously important in effective management of these collections. The expenses involved with

field work to collect mammals is continuing to increase, and because of this, newly collected specimens, as well as those already in collections, are of increasing value. The rapid rate at which natural areas are being destroyed in the world further increases the importance of mammal specimens in collections today, for there may never be the opportunity to sample some mammal populations again. For these reasons, curators should be dedicated to ensuring the permanent preservation of specimens under their care. There should also be an increased effort to maximise the protection for specimens by utilising storage equipment and supplies that will best afford this protection.

Historically, the selection of storage equipment and supplies has often been dictated by tradition. Each succeeding generation of curators in a collection might tend to use the same model, design, or brand of a particular item because previous curators had set the standard for such materials. The only factor that may alter this pattern in some cases is the nonavailability of some item, which forces the curator to seek different distributors or suitable substitutes for that item. The trend towards using the same equipment or supplies as previous curators, although important in some ways to the continuity and management of the collection, can result in an ignorance of product advancements. The benefits of new designs and improvements on existing products thus may not be realised by the collection, and ultimately might result in the loss of specimens that could have been saved.

Similar problems exist when curators build their own equipment or have it constructed by local craftsmen (e.g. specimen cases), if the plans or blueprints for such items are passed on from curator to curator through the years. In that situation, improvements on existing designs may never come to light.

The solution to problems such as those described above is in increasing communication among curators of mammal collections. This communication I believe is the key, not only to determining the supplies and equipment that best meet the needs of curators, but to solving many problems dealing with collection management in general. One means of increasing communication is through the publication of a newsletter specifically designed to address problems concerned with management of mammal collections. In the United States, the American Society of Ichthyologists and Herpetologists (ASIH) Ichthyological Subcommittee on Curatorial Supplies and Practices is producing "Curation Newsletter" as a means of increasing communication concerning collection management among curators of ichthyological and herpetological collections. I am not aware of any similar effort in the field of mammalogy, but such a newsletter in our discipline, if widely distributed, could have a

significant impact on improving the standards of management of mammal collections in many parts of the world.

A specific problem regarding equipment and supplies for most systematics collections is the limited market they provide for such items. The needs of individual collections or museums are usually not sufficient in terms of quantity of individual items to warrant production by major manufacturers. These manufacturers also cannot afford to invest the time or money to add product lines, or improve or redesign existing products because the quantities of these materials ordered by a few museums is insufficient to justify their expense. A case in point is represented by the need for good quality specimen jars; many curators are forced to purchase inferior jars because the best choice is simply not available. Lemche (1973) proposed a solution for such problems in the form of an international cooperative organisation to make very large purchases of museum supplies (in this case, specimen jars). The Scandinavian cooperation was organised through the Zoological Museum of Copenhagen, Denmark, which acted as the central purchasing agent for other museums. Such a cooperative venture could solve many problems of availability of collection supplies on a national or international basis.

In general, the curators of mammal collections should make an effort to evaluate storage equipment and supplies currently in use, identify problems or deficiencies that exist, and suggest improvements in the design of future materials. Communication concerning such problems and solutions among curators is one way to increase the possibility of permanent safe storage for specimens of mammals in collections today.

#### *Distributors or Manufacturers of Curatorial Equipment and Supplies*

The following list includes information on places to obtain storage equipment and supplies described above, as well as selected curatorial supplies used in many mammal collections. Obviously, all manufacturers or distributors have not been listed. An effort has been made to list one or more distributors from broad geographic areas; however, this has not been possible in all cases. The absence of distributors does not reflect product quality or availability. This list does not constitute a product endorsement for any distributor or manufacturer.

#### **Adhesives**

Royal Industrial Adhesive M6273; clear adhesive for sealing jars containing fluid-preserved specimens.

Uniroyal Plastics Products, Division of Uniroyal, Inc. Adhesives and Coatings Dept., 312 North Hill St., Mishawaka, IN 46544, USA.

3M Super Weatherstrip Adhesive (Part No. 08001); adhesive for fastening gaskets to large tanks for storage of fluid-preserved specimens.  
3M Company, 3M Center, St. Paul, MN 55101, USA.

### **Alcohol (Ethanol, Isopropanol)**

Carolina Biological Supply, Burlington, NC 27215, USA.  
Fisher Scientific Co., 711 Forbes Ave., Pittsburgh, PA 15219, USA.  
Southern Biological Supply Co., P.O. Box 68, McKenzie, TN 38201, USA.

### **Bags, Polyethylene**

Ziplip, Minigrip polyethylene bags in various sizes, weights, and styles.

Associated Bag Co., 160 South 2nd St., Milwaukee, WI 53204, USA.

Cole-Parmer Instrument Co., 7425 North Oak Park Ave., Chicago, IL 60648, USA.

Joka Plast-Emballage AB, Box 5144, V Ronneholmsvagen 62, 20071 Malmo, Sweden.

### **Bottles, Jars for fluid-preserved specimens**

Wide mouth jars with screw top closures of metal or bakelite, various sizes and styles.

Carolina Biological Supply, Fisher Scientific Company.

Southern Biological Supply Co., (see addresses above).

O. Berk Co., P.O. Box 605, 501 Park Avenue South, Linden, NJ 07036, USA.

J. Rabinowitz and Sons, Inc., 1300 Metropolitan Ave., Bklyn, NY 11237, USA.

Ampak Ltd., 2945 Andre, Dorval, Quebec, H9P 2R3, Canada.

Consolidated Bottle Co., P.O. Box 367, Station D, Toronto, Ontario, M6P 3J9, Canada.

Polypropylene screw lids with polyethylene liners for wide mouth jars.

Kol's Container Corp., 1408 DeSoto Rd., Baltimore, MD 21230, USA.

Mack-Wayne, 130 Ryerson Ave., Wayne, NJ 07470, USA.

Wide mouth glass jars with plastic snap-on lids (specially for museums), 70 ml to 3 litres capacity.

Kay R. Grathwol Aktieselskab, Dronningens Tvaergade 35, 1302 Kobenhavn K., Denmark.

Wide mouth bottles with Abico insert type liner; 70 ml to 8 litres capacity; also sell liners alone.

Abico Scientific Manufacturing Co., P.O. Box 12, Kashiwa, 277 Japan.

Gasket-type bottles, bail top and clamp top, with glass lids; various styles and sizes.

J. G. Durant, Wade Blvd., Millville, NJ 08332, USA.

Grant-Howard Associates, P.O. Box 639, 465 Canal St., Stamford, CT 06904, USA.

Wheaton, 1501 10th St., Millville, NJ 08332, USA.

Fedenza, 8300 NE underground Dr., Gladstone, MO 64118, USA.

A/S Christiania Glasmagasin, Postboks 8266, Hammersborg, Oslo 1, Norway.

Societe Francaise des Verreries Mecaniques Champenoises 147, Rue Ernest Renan 51, Reims B.P. 67, France.

Plastic bottles, 600 ml to 5 litres.

Xactics (Pty.) Ltd., P.O. Box 5012, 8000 Cape Town, South Africa.

### **Boxes for Skeletal Material**

Cardboard boxes made to individual specifications; for examples, see Appendix A.

American Packaging Co., Inc., 402 Lafayette St., New York, NY 10003, USA.

Helsingborgs Emballage AB, Box 5035, 250 05 Helsingborg, Sweden.

Kartongfabrikerna, Malmo Kartongfabrik, Olof Svenssons.

Kartongfabrik AB, Ankargripsgatan 4, 21120 Malmo, Sweden.

A.E. Long and Co., Ltd., 32 Cranfield Rd., Toronto, Ontario, M4B 3H4, Canada.

Rock-Tenn Co., P.O. Box 250, Mineral Wells, TX 76067, USA.

Thacker Container Co., P.O. Box 915, Addison, TX 75001, USA.

Plastic boxes for storage of small skeletal material.

Althor Products, Aspetuck Industrial Center, P.O. Box 1236, Weston, CT 06880, USA.

Semadeni AS, CH-3072 Ostermundigen, Switzerland.

Fiberglass tote pans for storage of large skeletal material; stackable containers with dustproof lids.

Cherokee Products Corp., 2933 Armory Dr., Nashville, TN 37204, USA.



**Capsules, Gelatin**

Various sizes for storage of small bacula and other skeletal material.  
Ernest F. Fullam, Inc., P.O. Box 444, Schenectady, NY 12301, USA.

Caligor Physicians and Hospital Supply, 1226 Lexington Ave., New York, NY 10028. USA.

**Capsules, Polyethylene**

Polyethylene capsules of various sizes with attached top, for storage of small bacula and other skeletal material.

Ernest F. Fullam, Inc. see above.

Ladd Research Industries, Inc., P.O. Box 901, Burlington, VT 05401, USA.

**Cases, see Specimen Cases****Catalogue Storage Cases**

Fireproof files for storing catalogues and records.

Acme Safe Co., Inc., 150 Lafayette St., New York, NY 10013, USA.

**Compactors**

Lundia Hyllor, Lundquists Snickerier AB, Box 40 056, 103 42 Stockholm, Sweden.

Lundia, Myers Industries, Inc., Jacksonville, IL 62650, USA.

Spacesaver Corporation, 1450 Janesville Ave., Ft. Atkinson, WI 53538, USA.

**Conservation Supplies**

General supplies for conservation and archival preservation of collection records, including such things as acid-free paper, envelopes, and boxes.

Conservation Materials, Ltd., 340 Freeport Blvd., P.O. Box 2884, Sparks, NV 89431, USA.

The Hollinger Corporation, 3810 South Four Mile Run Dr., P.O. Box 6185, Arlington, VA 22206, USA.

Light Impressions Corp., Box 3012, Rochester, NY 14614, USA.

Talas, 104 Fifth Ave., New York, NY 10011, USA.

University Products, Inc., P.O. Box 101, South Canal St., Holyoke, MA 01041, USA.

### **Desiccants**

Silica gel for modifying humidity conditions within cases.

Multiform Desiccants, Inc., 960 Busti at Niagara, Buffalo, NY 14213, USA.

### **Drying Cases**

Steel case with controlled heat for drying specimens; expanded metal trays.

The Steel Fixture Manufacturing Co., P.O. Box 917, Topeka, KS 66601, USA.

### **Fumigants**

Dowfume 75; 30 % carbon tetrachloride, 70 % ethylene dichloride.

Dow Chemical Co., Midland, MI 48640, USA.

Dimethyldichlorovinyl phosphate; DDVP, Vapona.

Bioquip Products, P.O. Box 61, Santa Monica, CA 90406, USA.

Texize, Division of Morton Norwich, P.O. Box 368, Greenville, SC 29602, USA.

Paradichlorobenzene; PDB.

City Chemical Corp., 132 West 22nd St., New York, NY 10011, USA.

Fisher Scientific Co., see address above.

Penn State Chemical Co., 324 East Thirteenth St., Topeka, KS 66612, USA.

Napthalene

Bioquip Products; see address above.

Penn State Chemical Co.; see address above.

### **Gas Masks, see Respirators**

### **Humidity Indicators**

Paper cards indicating percent humidity.

Conservation Materials, Ltd.; Multiform Desiccants, Inc., see addresses above.

### **Hydrometers, Alcohol**

Hydrometers with or without thermometers; with Tralle (%) scales.

Carolina Biological Supply, Fisher Scientific Co.; see addresses above.

### **Hygrometers**

Measure temperature and relative humidity.

Fisher Scientific Co., see address above.

Forestry Suppliers, Inc., P.O. Box 8397, Jackson, MS 39204, USA.

**Jars, See Bottles****Labels**

Labels for boxes for skeletal material; labels for jars with fluid-preserved specimens.

Locally available from printers.

100% cotton rag, water resistant paper for labels; Byron Weston Resistall Linen Ledger.

Byron Weston Co., Dalton, MA 01226, USA.

Waterproof plastic papers for labels; Polypaper, syntosil.

Fisher Scientific Co., Forestry Suppliers, Inc., see addresses above.

Zurich Paper Mill on Sihl, Postfach, CH-8021 Zurich, Switzerland.

**Map Cases**

Steel cases for flat storage of maps; various sizes and designs.

Forestry Suppliers, Inc., see address above.

Hamilton Industries, P.O. Box 137, Two Rivers, WI 54241, USA.

Lane Science Equipment Corp., 225 W. 34th St., New York, NY 10122, USA.

Steel Fixture Manufacturing Co., see address above.

**Respirators, Gas Masks**

Respirators and gas masks for safe fumigation of mammal collections; various styles and air filtration methods dependent on the fumigant used.

Forestry Suppliers, Inc. see address above.

Willson Products Division, ESB Incorporated, P.O. Box 622, Reading, PA 19603, USA.

Formaldehyde vapor masks (product No. 8754); disposable mask for eliminating formaldehyde fumes.

Occupational Health and Safety Products Division, 220-7W, 3M Center, St. Paul, MN 55101, USA.

**Specimen cases**

Steel cases with hinged or lift off doors, or both; some with recessed handles; drawers of metal or wood; various styles and sizes.

Interior Steel Equipment Co., 2352 East 69th St., Cleveland, OH 44104, USA

Lane Science Equipment Corp.; Steel Fixture Manufacturing Co.; see addresses above.

Wertheim, P. O. Box 192, A-1101 Vienna, Austria.

**Specimen Jars, see bottles****Specimen Tanks**

Rectangular stainless steel tanks for holding large fluid preserved specimens; three sizes available; wheeled dollies also available.

Steel Fixture Manufacturing Co., see address above.

Plastic pails with snap on lids for storage of fluid preserved specimens; sizes from 16 to 21 litres.

Carolina Biological Supply; see address above.

Letica Corp., Rochester, MI 48063, USA.

Plastican Inc., Leominster, MA 01453, USA.

Rectangular polyethylene tanks with covers; capacities 21 to 84 litres; some with locking lids and drainage plugs.

Agri-tainer Corporation, P. O. Box 2004, Wenatchee, WA 98801, USA.

Bel-Art Products, Pequannock, NJ 07440, USA.

Cole-Parmer Instrument Co., 7425 North Oak Park Ave., Chicago, IL 60648, USA.

Fisher Scientific Co.; Southern Biological Supply Co.; see addresses above.

### **Steel Shelving**

Heavy duty shelving for storage of large skeletal material or fluid-preserved specimens.

Alco Equipment, Division of Aleco Steel Equipment Corp., 3950 Tenth Ave., New York, NY 10034, USA.

Unistrut Building Systems, GTE Products, Corp., 35005 Michigan Ave. West, Wayne, MI 48184, USA.

Steel shelving with rollers that allow extension of shelves for access to stored tanks without removal from shelves; designed for storing tanks of fluid-preserved specimens.

Steel Fixture Manufacturing Co., see address above.

### **Trays for dividing specimen drawers**

Paper wrapped chipboard unit trays made to specifications; see Appendix B.

American Packaging Co., Inc.; Rock-Tenn Co.; see addresses above.

### **Ultra-violet light filters**

Film sheets for windows or fluorescent bulb sleeves.

The Modern Co., Lytham Rd., Heald Green, Cheshire SK8 3RQ, England.

Rohm and Haas, Independence Mall West, Philadelphia, PA 19105, USA.

Solar-Screen Co., 53-11 105th St., Corona, NY 11368, USA.

**Vials**

Clear glass vials with polyethylene stoppers; various sizes from one to eight drams.

Brockway Glass Co., Tubular Products, Division 67, Walnut St., Suite 103, Clark, NJ 07066, USA.

Poly Tops, P. O. Box 93, 1600 Isando, Johannesburg, South Africa.

Southern Biological Supply Co., see address above.

Plastic vials with snap-on caps; various sizes.

Brunnel Laboratories (Pty.) Ltd., P. O. Box 23103, 0031 Innesdale, Pretoria, South Africa.

Central Scientific Co., 2600 South Kostner Ave., Chicago, IL 60623, USA.

Poly Tops, Semadeni AS; see addresses above.

Watkins and Dorrcester, Fort Thames, Kent, England.

White Cross Surgical Medical Supplies, 260 Richmond St. West, Toronto M5V 1W8, Ontario, Canada.

**SUMMARY**

The safe storage of specimens is a primary concern of curators of Recent mammal collections. Extensive field collecting serves little purpose if specimens from such research activities are destroyed due to inadequate storage facilities or lack of maintenance. The storage equipment and supplies used in mammal collections are an important factor in insuring protection for these specimens.

The selection of storage equipment and supplies by curators is often dictated by tradition, i. e. the specimen cases, boxes, jars, and other items may be used in a given collection because previous curators had used those particular products. This trend can result in an ignorance of recent advancements in product designs, and potentially may affect efficient management of the collection. Increased communication among curators of mammal collections concerning curatorial methods, supplies, and equipment, especially on an international basis, can alleviate that problem and promote higher standards for curation of mammal collections.

Another problem regarding equipment and supplies in the museum field in general is the limited market for such materials. Major manufacturers often cannot invest the time and money to add product lines or improve, update, or redesign existing products because the demand for such materials is so low. For this reason, the personnel at many mammal collections build much of their own storage equipment (e.g. specimen cases) or have equipment built by local craftsmen. Again, however, the design of this equipment may be carried over from a basic

plan drawn up decades before. An effort should be made by curators to evaluate storage equipment and supplies currently in use, identify problems or deficiencies that may exist, and suggest improvements in the design of future materials used in mammal collections.

Information on storage equipment and supplies used in selected mammal collections throughout the world is provided. Important criteria for selecting certain storage methods, equipment, or supplies, and names and addresses of some manufacturers and distributors of these materials are provided.

#### REFERENCES

- DOWLER, R. C. and GENOWAYS, H. H. 1976. Supplies and suppliers for vertebrate collections. *Museology, Texas Tech Univ.*, **4** : 1-83.
- FINK, W. L., HARTEL, K. E., SAUL, W. G., KOON, E. M. and WILEY, E. O. 1979. Report on current supplies and practices used in curation of ichthyological collections. American Society of Ichthyologists and Herpetologists ad hoc subcommittee report, 63 pp.
- HARTEL, K. E. 1980a. EPDM replaces Buna-N. *ASIH Curation Newsl.*, **1** : 2-3.
- HARTEL, K. E. 1980b. Abisco 8 liter jars. *ASIH Curation Newsl.*, **1** : 3-4.
- HAWKS, C. A. 1988. Conservation considerations in mammal collections. *Proc. Wksp. Mgmt Mammal Colln Tropical Environ., Calcutta*, : 475-493.
- HAWKS, C. A., WILLIAMS, S. L. and GARDNER, J. S. 1984. The care of tanned skins in mammal research collections. *Museology, Texas Tech Univ.*, **6** : 1-32.
- JACKSON, H. H. T. 1926. The care of museum specimens of Recent mammals. *J. Mammal.*, **7** : 113-118.
- KNUDSEN, J. W. 1966. *Biological Techniques, Collecting, Preserving and Illustrating Plants and Animals*. xi+525, Harper and Row, New York.
- LEMICHE, H. 1973. A proposal for obtaining suitable museum glassware. *Curator*, **16** : 138-140.
- LEWIS, S. D. and Redfield, A. 1970. Care of osteological collections. *Mus. Briefs, Mus. Anthro., Univ. Missouri-Columbia*, **4** : 1-18.

PALMER, W. M. 1974. Inexpensive jars for museum specimens. *Curator*, 17 : 321-324.

VAN GELDER, R. G. 1965. "Another Man's Poison." *Curator*, 8 : 55-71.

WAGSTAFFE, R. and FIDLER, J. H. (eds.). 1968. *The preservation of natural history specimens. Volume 2. Vertebrate, botany, and geology.* xv + 404 pp., Philosophical Library, Inc., New York.

WILLIAMS, S. L. 1988. General considerations of collection storage and organization. *Proc. Wksp. Mgmt Mammal Colln Tropical Environ., Calcutta*, 241-270.

WILLIAMS, S. L., LAUBACH, R. and GENOWAYS, H. H. 1977. A guide to the management of Recent mammal collections. *Spec. Publs., Carnegie Mus. nat. Hist.*, 4 : 1-105.

APPENDIX A

*Trays for Use in Specimen Case Drawers*

Outside measurements for some trays used in the mammal collections of the American Museum of Natural History, New York, NY, USA (AMNH) and the Carnegie Museum of Natural History, Pittsburgh, PA, USA (CM). All measurements in millimetres.

<i>Length</i>	<i>Width</i>	<i>Height</i>	<i>Museum</i>
220	76	24	CM
328	76	24	CM
454	197	19	CM
303	84	25	AMNH
606	84	25	AMNH
304	228	25	AMNH
461	309	36	AMNH

Specifications: To be made of .048 white vat lined board and tight-wrapped with white litho paper.

APPENDIX B

*Boxes for Skeletal Material*

Outside measurements of some boxes used in the mammal collections of the American Museum of Natural History, New York, NY, USA (AMNH) and the Carnegie Museum of Natural History, Pittsburgh, PA, USA (CM). All measurements in millimetres.

<i>Construction</i>	<i>Length</i>	<i>Width</i>	<i>Height</i>	<i>Museum</i>
3-piece	62	56	49	AMNH
„	78	41	47	CM
„	100	62	49	AMNH
„	110	57	60	CM
„	138	74	66	AMNH
„	166	84	70	AMNH
„	166	84	76	CM
2-piece	208	135	107	AMNH
„	298	147	52	AMNH

Specifications for 3-piece box:

(Note: Part B fits within Parts A and C).

Part A (box lid)—To be made of .048 white vat lined board and tight-wrapped with kraft paper.

Part B (tray)—To be made of .048 vat lined board and tight-wrapped with white litho paper and glued in to the base (Part C).

Part C (box base)—To be made of .048 plain chipboard and tight-wrapped with kraft paper.

Measurements for Part B are such as to allow for a snug fit within parts A and C. Part B height shall be sufficient to reach to within 6 mm of the inside top of Part A when box is closed.

Specifications for 2-piece box:

Both parts to be made of .036 or .048 plain chipboard and tight-wrapped with kraft paper. Measurements of bottom are such as to allow snug fit within top.



## DISCUSSION

- Q. Usually the glass jars containing formalin develop cracks (become brittle) in the lid portion after a few years. How can it be avoided ?
- A. Cracks in bakelite and glass lids are caused by fluctuations in temperature and humidity. The solution is to store collections in such an area where constant temperature and humidity are maintained. Also neutral formalin should be used to prevent release of formaldehyde at higher temperature.

## **STORAGE EQUIPMENT AND SUPPLIES**

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### **INTRODUCTION**

“Theoretically it should be possible to preserve an object indefinitely by placing it in a hermetically sealed container filled with an inert gas with a fixed level of relative humidity and kept in the dark in low temperature” (Stolow, 1966). This objective can never be reached in museums for two reasons—(i) depriving researchers to examine specimens for scientific study, (ii) depriving members of the public from viewing zoological specimens and enjoying wonders of animal world. The major concern of this workshop is with the first point of reference and centres around management of Recent mammal collections in tropical environment.

### **ROLE OF ENVIRONMENT ON ZOOLOGICAL COLLECTIONS IN THE TROPICS**

Tropical environment has some characteristic features which are distinctively different from temperate conditions. Humidity and temperature coupled with dust and pests pose major problems under an unstable environmental condition.

At low humidity level, material may dry out, whereas at high humidity level organic material absorbs moisture and expands (Figs. 1 and 2). Most damaging conditions occur due to rapid fluctuation, with material undergoing shrinking and swelling in an unstable condition. To control such situations, an expensive central humidity control system or a local humidifier or dehumidifier, such as silica gel in crystal form, is recommended (Green, 1978). Simultaneously, effective recording of temperature and humidity all through the year at different sites within the storage area is essential to monitor conditions.

Light, both visible and invisible, may damage specimens of organic nature by fading of pigment, dye and by physical deterioration. Fluorescent light is usually recommended instead of daylight and working areas should appropriately be separated from storage area to avoid exposure of the latter to light for a longer period.

In a tropical country like India, the dust factor poses a major problem. With heavy dustfall of both particulate material and others, storage area in urban centres like Calcutta becomes vulnerable to dust and dirt. An effective air filtering system or proper storage cabinets with dust-proof doors is or are needed to combat the menace.

The pest (both insect and non-insect) problem may also become alarming in tropical conditions due to naturally favourable conditions for their growth and development. Fumigation with selective chemicals to control moulds or insects remains the most effective measure. Use of repellents, such as a mixture of chloroform, naphthalene and creosote or paradichlorobenzene, in storage space is recommended for proper maintenance of collection.

The Zoological Survey of India (established in 1916) inherited a substantial amount of material from the Indian Museum (established in 1814) which institution in its turn received material from the Asiatic Society of Bengal (established in 1784). These specimens underwent the typical environmental conditions of Calcutta with distinct seasonal fluctuations of humidity, temperature and daylight period.

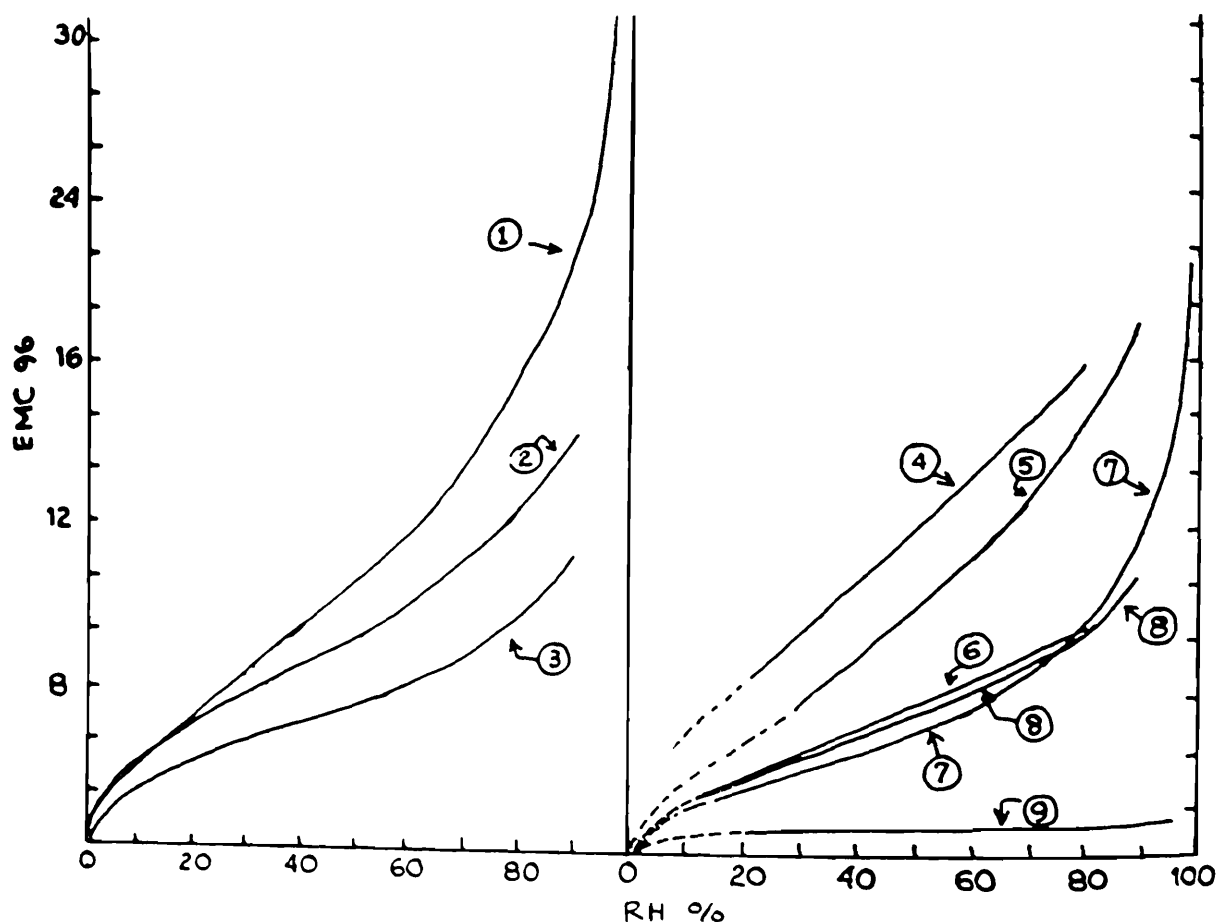


Fig. 1. Effect of change in relative humidity (RH) on the equilibrium moisture content (EMC) for various moisture sensitive materials at room temperature: 1. Wood; 2. Kraft paper; 3. Newsprint paper; 4. Fir plywood; 5. Homosote board; 6. Masonite board; 7. Cotton; 8. Linen; 9. Styrolite; (expanded polystyrene, density 0.02 gm/cc.) (from Stolow, 1966).

The moisture and relative humidity (RH) play important role in preservation of these specimens in wooden cabinets. It is well-known that wood being moisture-sensitive, would absorb water vapour from the atmosphere according to the relative humidity. Consequently, wood changes dimensions. The RH-gradient with low and high level can often lead to cracking and in case of one-sided painted surface, flaking of paint. The contents of such cabinets, especially study skins, etc., obviously become exposed to damage by fungi, other pests and dust. Increased temperature will also effect a decrease in the equilibrium moisture-content. The growth of mould becomes conducive at RH above 80% and temperature above 20°C.

However, the consideration of environment should be aimed at in terms of local climate. Even within a broad framework of tropical environment, considerable variations with respect to relative humidity, temperature, precipitation and wind-direction can be well evidenced (*e. g.*, Calcutta, Jodhpur, Shillong, Madras : in January, on the same date, Calcutta may have temperature at 26°C, Shillong 16°C and Madras at 30°C).

A case study can be presented from the Zoological Survey of India.

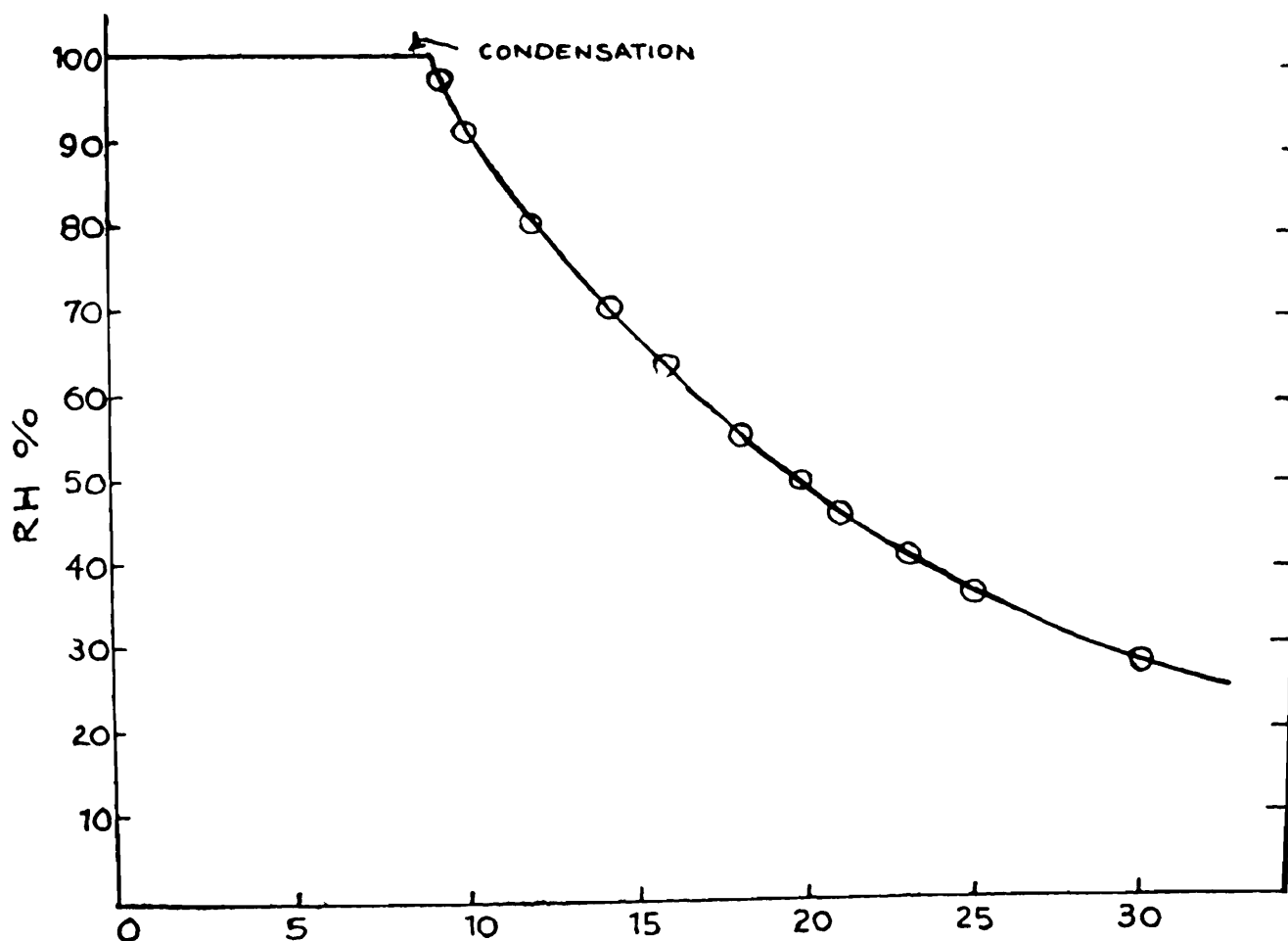


Fig. 2. Relationship between RH and temperature of air in a confined space originally at 20°C and 50 percent RH. The "plateau" indicates condensation. (from Stolow, 1966).

## COLLECTIONS IN THE ZOOLOGICAL SURVEY OF INDIA : A CASE STUDY

Many of the mammalian specimens in the Zoological Survey of India date back to the 19th century, but only in 1955 the dilapidated condition of wooden cabinets storing the collections was noted. Replacement was considered and vermin-and dust-proof steel cabinets with light-weight trays were recommended for the purpose.

On the basis of blueprints prepared as per instructions of the Survey officials, a noted manufacturer of furniture designed two items.

The first item, steel cupboards, measured 137 cm in height, 122 cm in width and 61 cm in depth externally. Each cupboard was designed to be fitted with one central vertical channel frame partition (removable) dividing the cupboard into two equal compartments. In each cupboard, angles, each 2 cm by 86 cm by 41 cm, were proposed to be fitted along the depth, for holding the trays. A total of 25 steel or plastic trays, each measuring 4 cm in height, 48 cm in width at top and 53 cm in width at bottom, and 56 cm in depth, would be housed in each cupboard. Each cupboard could be enclosed in front by a pair of hinged steel doors, with door-rubber linings (Fig 3).

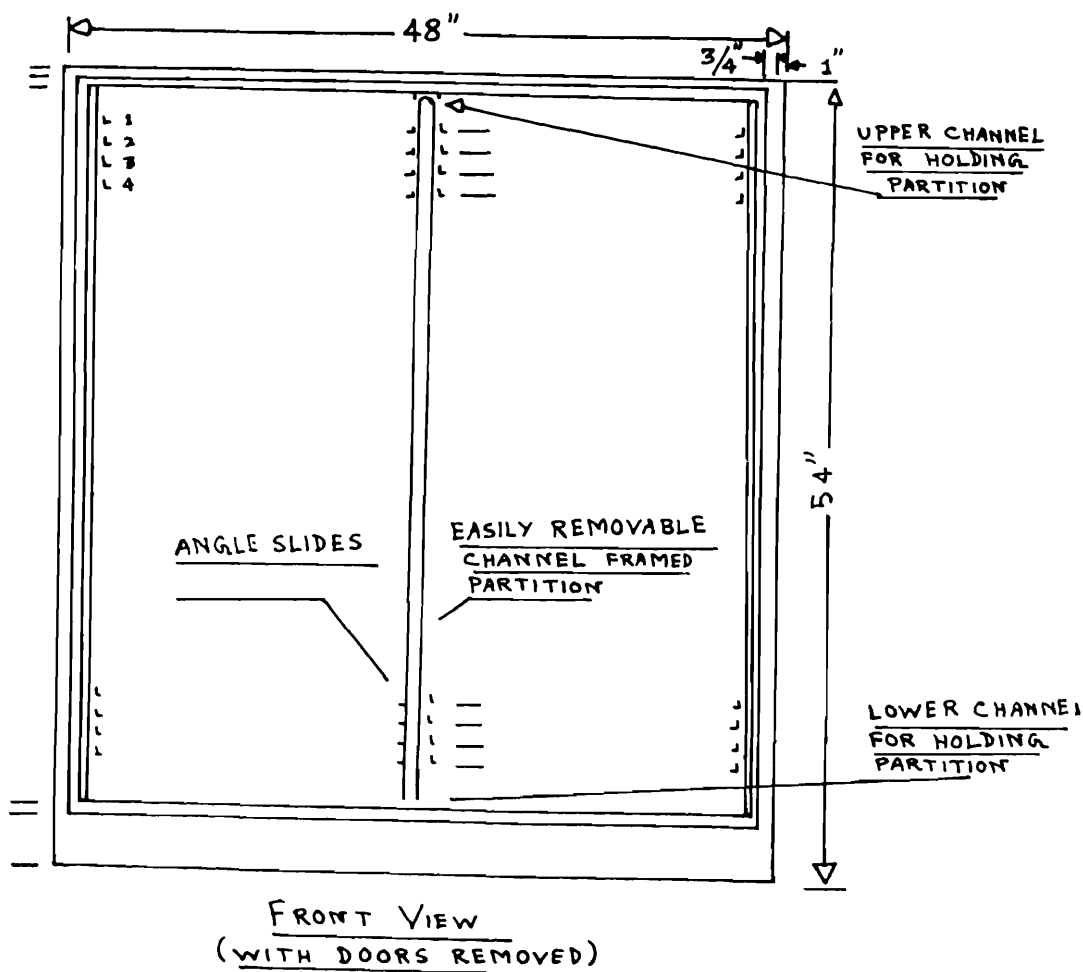


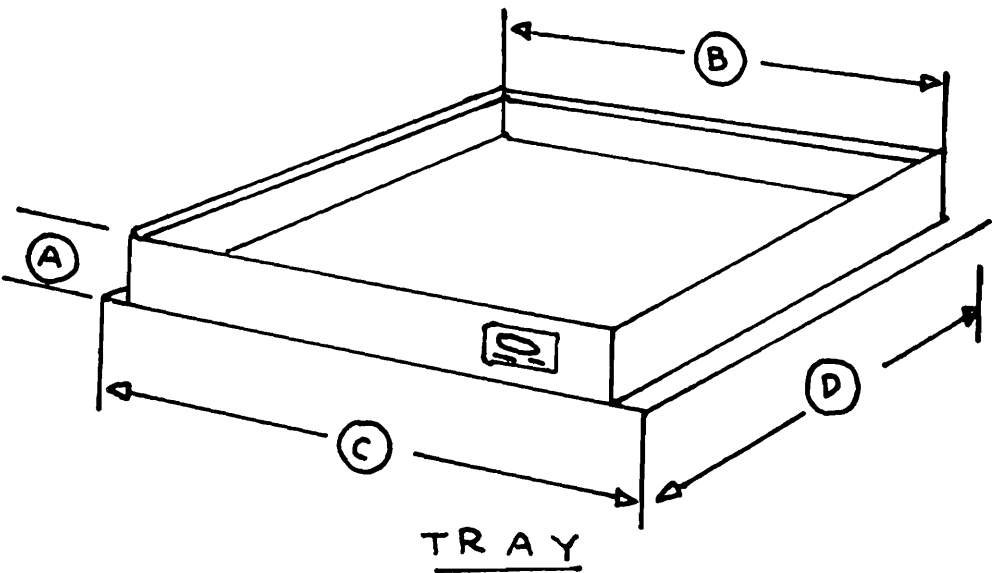
Fig. 3. Cabinet, front view.

In the second item, the cupboards would not have vertical partitions and each cupboard would have seven large trays, each measuring 9 cm in height, 105 cm in width at top and 56 cm in depth externally (Fig. 4).

However, even after 30 years, no such cupboard could be prepared through commercial enterprise, largely because of long-drawn administrative controversy on cost-benefit ratio and effects of change of conventional wooden cabinets to ones much better suited against environmental changes.

The skeletal preparations, both appendicular and cranial, also faced severe problem of storage. The use of open shelves with slotted-angle device is often recommended for large skeletons and fossil mammals. In a tropical environment complete protection from dust, dirt and pests can be ensured by covering the material with polythene sheets. Small skeletal collections can be kept in metallic drawers of cabinets, instead of plastic trays.

In any case, individualised care for cleaning and dusting as a routine work is essential in tropical conditions. The dearth of storage space often leads to mismanagement, crowding of material in haphazard manner and severe deterioration in the condition of specimens.



MEASUREMENTS OF TRAYS		
SIZES	SMALL TRAY	LARGE TRAY
(A)	1 <sup>5</sup> / <sub>8</sub> "	3 <sup>1</sup> / <sub>2</sub> "
(B)	19"	41 <sup>1</sup> / <sub>4</sub> "
(C)	21"	43 <sup>1</sup> / <sub>4</sub> "
(D)	22"	22"

Fig. 4. Size of trays.

## DISCUSSION

The storage of collections in the tropics depends on multiple factors, viz.,

- (1) Space allocation (floor) in the building
- (2) Height of ceiling, to calculate size and number of cabinets
- (3) Regular monitoring of collection
- (4) Proper storage equipment to ensure long-term preservation
- (5) Airconditioning to regulate relative humidity, moisture, also dust and microbes
- (6) Continuous power supply.

A problem in a developing country remains in the non-availability of desired storage equipment. As the demand for such specialised items remains low, no competent commercial enterprise feels interested to include such items in its regular manufacturing list. Special fabrication remains to be the only solution, but the cost in such a case will always be much higher and can create problems in purchase.

The design of floors, in a composite collection holdings, to conform with the desired result, remains another problem, where all collections, both dry and wet, including invertebrates and vertebrates are housed in the same building, the design usually remains a standard floor lay-out. The care, that every group of animal collection requires in storage, being different, (including use of storage equipment), much of specialisation can be prescribed in a theoretical way, but can never be implemented.

The recording instruments also sometimes pose problems as for their precision and maintenance. Imported items being restricted, the situation remains difficult. Airconditioning on the other hand has been tropicalised, but supply of power for central or package airconditioning appears to be another problem.

However, a proper device, controlled environmental condition, proper preparation of material in the field, and continuous monitoring of material, can be listed as most relevant points for consideration for the management of mammalian collections in the tropical regions. Funding perhaps remains the singular stumbling block in such endeavours.

## SUMMARY

Tropical environment has some characteristic features which are distinctively different from temperate conditions. High moisture-content and temperature-gradient coupled with dust and pests often

create problems in proper storage of zoological collections including mammalian specimens. The experience of more than 100 years of storing museum specimens in the city of Calcutta and the resultant remedial measures which one can recommend to overcome identified problem areas, however, may not hold good for other localities in a tropical country like India. As such, an uniform design of storage equipment to suit all the 15 regional centres of the Zoological Survey of India, is hard to conceive. However, special steel cabinets with plastic trays and door-lining of rubber have been designed by the scientists of the Zoological Survey of India, which if properly fabricated, are expected to provide maximum protection of mammalian specimens against damaging abiotic and biotic factors.

Larger skeletal preparations can be accommodated in open shelves with slotted-angle facilities, whereas the smaller skeletons can be kept in metallic drawers of cabinets. Large skeletons should be covered with thick polythene sheets.

Airconditioning of collection rooms in a tropical environment is essential for proper storage. However, funding of such a scheme always poses problem in developing countries. Even if the fund is made available, the ever-increasing power crisis poses a severe threat. These inherent difficulties can, however, be overcome by proper planning of the building, floor-space, cabinet-size, present holding and future provisions along with adequate funding.

#### ACKNOWLEDGEMENTS

The author is thankful to Dr. B. Biswas, Emeritus Scientist, Zoological Survey of India, for his kind comments on the appropriate device for storage, Dr. K. C. Jayaram, Joint Director, for inviting the author to deliver the lecture and to Dr. B. K. Tikader, Director, Zoological Survey of India, for facilities.

#### REFERENCES

- GREEN, C. S. 1978. Storage techniques for ethnology collections. *Curator*, **21** : 111-128.
- STOLOW, N. 1966. The action of environment on museum objects. Part I : Humidity, temperature, atmospheric pollution. *Curator*, **9** : 175-186.





## **MAMMAL COLLECTIONS IN INDIA : HISTORY, PROBLEMS AND PROSPECTS**

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In 1957, H. S. Rao wrote a review of the knowledge in India of its fauna through the ages. It is evident from this well written exposition that knowledge and interest in India's fauna dates back to the early years of recorded history. He recognises three periods, the (a) Vedic and Sangam literature of Tamil Nadu Period (b) Sultanate and Moghul Period and (c) Post Moghul to Modern times. It is in the last period that the systematic study of the fauna commenced with the introduction of western science into the subcontinent. This was through the arrival of the British and the French, who, particularly the former, came as traders and remained as conquerors. This new and alien concept took root and a serious study of Indian mammals began in the early years of the 19th Century. It is likely, however, that the Indian fauna, particularly, the larger mammals, were known to Western Science as is evident from the naming of such species as the leopard by Linnaeus in 1758, but these were evidently the description of menagerie animals.

The pioneer in the collection, identification, and naming of India's mammalian fauna was Hardwicke. He served as a Major General in the army and used this opportunity to travel for collecting specimens, which he had sketched in colour, using the services of indigenous artists. Among a number of animals that he described are the Goral (*Naemorhedus goral*) and the Indian Gerbil (*Tatera indica*). Hardwicke retired to England in 1823 and between the years 1830 and 1835 collaborated with J. E. Gray of the British Museum in the publication of the well known "Illustrations to Indian Zoology"

It is now the time to consider the French interlude in the study of Indian mammals. The contribution they made was substantial during the first three decades of the 19th Century. Their names will be well known to those familiar with the taxonomy of India's mammals, birds, reptiles, and amphibians. The first to arrive was Jean Baptiste Leschenault de la tour, who came as the keeper of the Royal Botanical Gardens at Pondicherry, in 1826 and returned to France in 1836 after collecting widely in southern India and Sri Lanka. Pierre Medard Diard reached Chandranagore in 1817 and in the company of Alfred Duvacel, Cuviers' step son, collected widely in eastern India and Southeast Asia. Both died in the east, Diard at Batavia in 1863, and Duvacel in Madras in 1824.

Another active French collector of this period was Dussumier, who was a Captain in the French Mercantile Marine. The next to arrive was Victor Jacquemont, who was more of a bon vivant than a collector. The only species to his credit is *Marmota caudata*. Jacquemont died in Bombay in 1832. A more successful collector was Charles Belanger who reached Bombay in 1825, collected along the west coast, discovering several new mammals and then proceeded east to Java through Pondicherry. The last among the French travelling naturalists was Adolphe Delessert, but his interest was largely in birds. The specimens that these naturalists collected were studied in Paris and described by the Cuviers, Geoffroy, Blainville, and others and one comes on them repeatedly in the names of the land vertebrates of the Indian Subcontinent.

The British had the time and opportunity for a leisurly and comprehensive study and for consolidating the knowledge contributed by the pioneers. The necessary infrastructure in the form of museums for holding collections and scientific journals for publishing the results of their study were available or were created. The Company's Museum in London in the early years of the 19th Century and the British Museum formed major repositories in Britain, whereas the Asiatic Society and the Indian Museum organised at Calcutta in the latter half of the 19th Century. The keepers and curators of these museums, Horsfield and Gray in Britain and Blyth and Anderson in Calcutta, formed the focal point for the study and report on collections which were published either in the Journal of the Zoological Society of London or the Asiatic Society of Bengal or Journals such as the "Madras Journal of Literature and Science" published by local enthusiasts. Some of the British naturalists who left their mark on Indian mammalogy either through collections alone or collections and their description are W. H. Sykes, Walter Elliot and T. C. Jerdon for the Penninsula, Brian Hodgson for Nepal, John McClelland, Tickell, Barbe and others for the Himalayas and eastern India. The history of the study of mammals in the 19th Century has been dealt with elaborately by Norman Kinnear in his article "The History of Indian Mammalogy and Ornithology" published in two parts in the Journal of the Bombay Natural History Society, Volumes 50 and 51. I shall not, therefore, go into more details here.

Systematic collection over a wide geographical area as opposed to collection by individuals in particular regions was only undertaken with the advent of the Bombay Natural History Society and its Mammal Survey between the years 1911 and 1923. In the year 1911, the Committee of the Society decided to undertake a systematic survey of the mammals of India, Burma and Sri Lanka.

The purpose of the Survey was to secure a systematic series of carefully preserved skins and skulls of the mammals of the Indian region and

Sri Lanka, collected in different provinces, in order to provide the material necessary for comprehensive study of the status, variation, and distribution of species. Such material was non-existent. The collection of Indian mammals in the British Museum and in the museums in India were remarkably inadequate.

The Society's collection of mammals had been built by its members. However, it was realised that a task of the magnitude of the proposed Survey could not be left to the efforts of private collectors. It was work which could only be effectively carried out by trained collectors expressly employed for the purpose and at no small expense. The Society, therefore, issued an appeal for funds for carrying out the survey. The response from its members was immediate. By the 1st of April 1911, over Rs. 10,000 had been subscribed in sums ranging from Rs. 5 to Rs. 2,000. Several of the Indian Princes on the roll of the Society supported the survey very generously. Before the end of the year the Mammal Fund had increased to over Rs. 20,000. In the following year 1912, the Government of India and most of the Provincial Governments interested themselves in the survey and helped it with generous grants. Contributions were also received from the Government of Sri Lanka and the Government of the Federated Malay States so that by the end of 1913 the fund had swelled to over Rs. 66,000 and in May of the following year it reached Rs. 80,929. Contributions were received from the Trustees of the British Museum, the Royal Society, the Indian Museum, Calcutta, and other scientific bodies.

Between 1915 and 1919 Rs. 15,000 were received in donations from members, while a grant of Rs. 50,000 from the Government of India enabled the Society to engage new collectors to carry on and complete the survey which was brought to a close in 1923.

The Survey covered selected areas in western, central and eastern Himalayas, Assam and states in eastern India ; Baluchistan and Sind, Gangetic Plains, the Peninsula, Sri Lanka, and Burma.

The value of the collection obtained by the Survey lay firstly in that, for the first time a series of carefully prepared specimens of Indian mammals, obtained in different areas of their habitat were available and thereby furnished data for the investigation of problems related to their variation and distribution. Secondly, in deciding the areas in which the collectors worked, a special effort was made to cover the districts in which the earlier naturalists collected.

No advance in systematic mammalogy was possible without the re-examination of material illustrative of the species named by the earlier writers. The type specimens on which the written descriptions of these

species were based, were in many instances no longer available. The Survey provided a series of topotypes obtained in the localities from which the "types" originated.

The collection made in the Dharwar District where Sir William Elliot collected 70 years previously, provided topotypes of no less than eight species named by Gray from specimens obtained by Elliot. Collections from Bengal, Bihar, and Orissa again furnished a number of specimens which represented "types" which have either disappeared or were no longer available for examination. Collections from Sri Lanka furnished data, the absence of which had made it impossible to work out several Indian species which had originally been described from Sri Lanka and which had remained doubtful till the Survey was carried out. While collections from Nepal by providing 'topotypical' material for judging the many nominal species described by Hodgson as peculiar to Nepal, proved one of the most valuable contributions made by the Survey to Indian mammalogy. The Survey further provided valuable evidence relative to the general distribution of mammals in the region which it covered. It indicated the extent of the intrusion of 'northern' forms into the Peninsula Region and provided valuable evidence relative to the extent of the incursion of the 'plains' fauna into the Himalayan region as was illustrated by the discovery in the mountains of Chamba and Sikkim of such obviously low country species as the common fox and the five-striped squirrel. The Survey also gave a more exact idea of the distribution of species in southern India and Sri Lanka.

Particularly interesting from the standpoint of distribution were the collections made along the great barrier chain of the Himalayas. The magnificent collection from Sikkim showed that a sharp line of demarcation existed at about 28° N between the two distinct faunas, i.e. the Palaearctic in the north and the Oriental in the south. This was indicated by the juxtaposition of such Palaearctic genera as voles, mousehares, water-shrews, marmots and musk deer with such characteristically Oriental forms as flying foxes, tree-shrews, civets, mungoose, bamboo rats, and barking deer. Further the collection indicated that the area is a meeting point of the Indian and Malayan faunas of the Oriental Region as was instanced by the numerous kinds of squirrels represented in the collection which did not occur in the Indian Peninsula but were widely distributed through Burma, western China and Thailand. The intrusion of these Malayan forms along the Himalayan chain weakened as one travelled westward.

The Survey material again furnished frequent data relative to the distribution of individual genera and species. The magnificent collection of squirrels numbering 400 specimens obtained on both banks of the Chindwin River provided striking evidence that this river forms a barrier

to the westward extension of the different species of squirrels. The species inhabiting the west and the east of the Chindwin river were found to be generally referable to two different groups, thus indicating that the separation had been of long standing, long enough for the groups on each bank to have respectively evolved a rich series of subspecies found in succession from north to south.

Forty-seven reports of the collections obtained by the Survey and worked out at the British Museum were published in the Journal of the Bombay Natural History Society. They form useful local lists indicating the various species obtained in the different localities in which the Survey operated.

While the descriptions of the earlier writers covered fairly completely the various species of mammals occurring in India and Sri Lanka, the Survey was instrumental in bringing to light several new genera and a large number of new species, some of them of a very striking character.

As was expected, the collections furnished splendid material for the study of variation which resulted in the description of numerous racial forms based on an examination of series of specimens collected over a wide area. The material also made possible and necessary the revision of various groups and genera which could not have been undertaken without the ample data provided by the Survey.

The enormous collection obtained by the Survey numbering over 50,000 specimens were worked out in detail at the British Museum by various authorities. The taxonomic results of the Society's Mammal Survey appeared in 47 papers entitled the "Scientific Results of the Mammal Survey". The substantial results so recorded form together a tremendous contribution to the progress of Indian systematic mammalogy.

The Survey collectors were not always able to make complete collections of animals from the districts in which they worked or to visit every part of the area. Again the collections in a given area were only made in one season. The magnificent series of squirrels including 200 specimens thoroughly illustrating the squirrel life of both sides of the Chindwin River over a distance of 400 km had one flaw, it was secured only in one season of the year and could provide no means of studying seasonal variations, if any. Again though a splendid collection comprising 749 specimens was obtained in the Dharwar district during the 4 months collection in the area, a few months subsequently a new bat, a large, and showy species, was discovered not even 64 km from the locality covered by the Survey.

The Survey remains as one of the finest contributions ever made by an amateur Society to the cause of scientific progress. The majority of

the Survey collections are now housed at the Society and form an immensely valuable holding from the fact that many of the species, for instance *Callosciurus* squirrels from Burma are presently unobtainable.

It is now time to consider the problems faced by non-governmental organisations holding collections. There is unfortunately no consolidated list of organisations holding mammal and other collections and, therefore, it is impossible to assess the quality of maintenance and study of such collections and the shortfalls. The listing of institutions holdings natural history collections, their present status and value, I am not here confining myself to mammals, is a matter of urgent priority. The Society's collections are not perhaps in such dire straits as collections in universities and smaller museums would be. The main problem is funds and inadequate staffing, for instance the Society receives funds for maintenance establishment from the State Government in the form of grants for four research assistants to maintain and work on a collection of over 1,00,000 specimens of all groups. No other assistance either from State or Central Government is received in spite of the fact that our holdings are considered part of the national collections. In spite of these handicaps, the Society maintains its collections at a good level. Curatorial functions suffer, I am certain, with collections held in small organisations such as museums funded by municipalities and universities as such collections are given very low priority, hence, as I indicated earlier the need for a status survey of mammal collections held in the country is an immediate necessity. Another major problem is the impediment to field research as a result of the interpretation of the Wildlife Protection Act by State Forest Departments. It is unfortunate that applications for collecting permits for research purposes are equated by Forest Departments at par with requests for permits from persons or organisation doing commercial trapping. The inability of forest departments to understand research needs is perhaps one of the reasons why royalties are charged for scientific collections. Permits for collecting for scientific purposes and for conducting scientific studies on wildlife should not be within the purview of Forest department but should be issued by the Department of Environment, Government of India. Unless this major handicap is removed, there is very little scope for development of taxonomic studies in this country.

It is an unfortunate situation that in present day there is no interested amateur in India studying mammal-taxonomy. This is, reflected in the status of private collections, for instance, the Bombay Natural History Society has not had a single large scale mammal survey programme since the Mammal Survey ended in 1923. The collection has been static except for the odd specimen brought in casually by researchers in other fields. The only two organisations that are involved currently in the study of mammal taxonomy are the Zoological Survey of India and the National

Institute of Virology, Pune. In the case of the latter it is an off shoot of their primary interest, the study of virus and virus infections.

In my opinion, the most urgent and immediate need is the identification of mammal collections held in this country whether in museums, colleges, or other institutions. Once collections have been identified, it is necessary to do a status survey to determine the quality of material held and the quality of the data that is available on them. It will be then necessary to evolve an uniform code for required data and how far each of the collections meet this desired criteria. Once an uniform data base has been achieved it is essential to feed the data into a computer, devising a programme that will enable retrieval of information available on any species in the collections in the country. Such a computer programme, in course of time should be an international effort so that a researcher on any particular family, genus, or species would be able to obtain information on holdings of that species throughout the world.

The direction in which future research based on collections should take is a matter which requires careful thought. It has to be recognised that collections have considerable educative value and this facet has been hardly used in India. Basic collections of species occurring in an area or illustrating an ecological niche should form an essential teaching adjunct. Collections should meet the requirement of species specific studies, such as the limits of distribution of a species, racial variation, sympatry, and preparation of distribution maps, which should be constantly updated to determine the status of a species in its habitat. Species specific collections open a wide field of study based on collections and require urgent attention in India presently to monitor environmental changes. The presence or absence of a particular species could be an indication of environmental health. Another study that is worth undertaking is to resurvey areas from which collections had been obtained previously ; for instance localities collected by the Bombay Natural History Society, during its Mammal Survey between 1911 and 1923. If such surveys could be undertaken in the same period of the year when the earlier surveys were conducted, the present status would give an indication of the status of the particular environment. This would be an interesting exercise as regards the comparative status of fauna of particular habitat over a period of years. Finally, the aim of organisations holding natural history collections should be to build up a collection which reflects the status of a group or a species through all seasons in a year throughout its distribution. Such a collection will be as useful for reference as a dictionary not only to taxonomists but to others working on allied fields of enquiry as well.

#### SUMMARY

The paper describes the origin and history of mammal collections in India, and the role of the amateur in the study of Indian Mammals.



The present status of mammal collections, their maintenance, study and the problems and prospects of mammals and mammal collections in India are described.

#### DISCUSSION

- Q. Would you please elaborate on the use of plastic trays-specific problems, benefits, etc.—and how these are suited for specimen-storage?*
- A.** Easy handling and cleaning ; specially suitable for small mammals and birds ; have not had breakages so far. Once the mould is made by the manufacturer the cost goes down.

## **PROBLEMS IN ESTABLISHING AND MAINTAINING A NEW COLLECTION OF MAMMALS : ETHIOPIA**

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### **INTRODUCTION**

Ethiopia is one of the few important centres of animal diversification because of its wide range of climatic, geographical, and topographical conditions. The variable topography of Ethiopia ranges from 100 m below sea level at Dallol in the Danakil depression (northeast Ethiopia) to over 4500 m above sea level in the Simien and Bale mountains. Sixty-two percent of the total area of the country lies in the lowland regions while the massifs and plateaus comprise about 38 percent (Mesfin, 1970). Over 50 percent of African highground above 2000 m is in Ethiopia (Yalden, 1983). The most compact and extensive highlands are found in Ethiopia. With the variation in altitude there is a marked difference in climate, vegetation, and land use (Daniel, 1969).

Communities of settled agriculturalists, nomadic pastoralists, and hunter-gatherers form the basis of this socially varied country (Tewolde Berhan, 1972). The misused and abused natural resources need further improvement based on a detailed study of the ecological relationships among land, vegetation, and animals. This will be enhanced if adequate determination of the animal species of the country is made.

Although some explorers have managed to collect some specimens from different accessible regions of Ethiopia, when compared to the diverse fauna, the country seems virtually untouched. Scott (1958) compared this incompletely surveyed condition in Ethiopia with that of many African countries and attributed this lack of completeness partly to the difficulty of travel. The Ethiopian highlands both in the north, central, and south are virgin grounds for specialists. Despite intensive work there are still many inadequately known species as well as regions in Africa (Haltenorth and Diller, 1980). Delany and Happold (1979) stress the little known and poorly studied fauna of the Ethiopian highlands. These areas are known to accommodate an exceptionally large number of species of endemic mammals as compared to the other African montane regions. Settlement is highly restricted in the extreme montane regions due to a

harsh climate. Besides, many explorers do not stay long in these areas. This will result in inadequate trapping and collection and poor representation of the species. Many species of mammals are small and inconspicuous with secretive habits resulting in poor representation. The rain forests of Ethiopia are also poorly known because of the inaccessibility of the region by earlier collecting expeditions (Brown and Urban, 1970). The status, distribution, and general ecology of the Ethiopian wildlife is poorly surveyed and much field work and investigation is essential to obtain the basic information (Blower, 1969). Despite the poor survey, the country is still of great biological interest and importance where the two biogeographical regions of the world intermingle (Largen, 1969). Zoogeographically, Ethiopia's fauna is of East African type with a small proportion of Palaearctic species (Mathews, 1977). Morris (1968) relates the high endemism of Ethiopian species to the large area of high plateau and its isolation from neighbouring mountain areas. It is obvious that the country has neglected and depleted its wildlife resource and still, fair populations of many African and endemic species exist in addition to the finest mountain scenery in Africa (Brown, 1973).

Some of the few publications on Ethiopian mammals include Thomas (1903, 1928), Allen (1939), Largen *et al.* (1974), and Yalden *et al.* (1976, 1977, 1980). A fair knowledge on most of the Ethiopian mammals with their distribution can be obtained from these publications. More revisions of groups could also be carried out as adequate collections accumulate from time to time. Additional information can be obtained from different explorers. But published facts regarding mammals are scattered through a vast amount of literature printed in many languages or rare publications (Walker, 1975). A developed country might easily get access to these publications as compared to a developing country. When it comes to the Ethiopian situation, the problem of getting information on the distribution and ecological and behavioural studies of mammals is highly aggravated. It is usually concluded that studies on the East African fauna might broadly represent the fauna of neighbouring countries and, as more information becomes available, the pattern of distribution might not diverge much (Kingdon, 1971). The absence of adequate information on the distribution of Ethiopian mammals has retarded the publication of many findings based on a regional scale.

#### ESTABLISHING AND MAINTAINING COLLECTIONS

In a developing country like Ethiopia where virtually no research tradition has been established and where foreigners have limited access, the problems are severe to establish and maintain new collections. For most people, allocation of money for this purpose is considered as a

wastage. Most of the initial problems in starting and maintaining collections are an absence of a transport network in most of the inaccessible regions, rugged physiographic features, extreme variations in climate, people's tradition, lack of trained manpower with a fair knowledge of ecological areas and volume of extant collections, absence of free exchange of experiences and cooperation with different governmental institutions, inadequacy of reference materials, and financial handicaps to expand space and buy chemicals and equipment.

Due to the rugged features of the country, the terrain in most areas is inaccessible unless one uses mules. In other areas, dry weather roads only connect the capitals of governorates. One has to be self-contained to explore many of the regions. In addition, the small rivers can easily swell during the season, block all available connections with other areas and make transport difficult because of muddy ground. This problem is beginning to be easily alleviated in some regions because of the construction of new roads.

A big programme is underway to eradicate illiteracy within the shortest time possible. This is likely to change the people's outlook. At present, preserving wild animals is not tradition in Ethiopia. Ethiopia consists of predominantly agricultural areas together with nomadic and hunter-gatherer life. Coupled with this are dozens of tribes with their own languages who are mostly at feud with each other and hostile to explorers irrespective of their mission. An individual's expectation of getting aid in many inaccessible regions should be minimal. In addition, some regions still possess the traditional culture where people gain status by killing larger mammals. These people are without an awareness of the potential extermination of these large mammals due to hunting pressure. This pressure of uncontrolled hunting is the greatest threat to the wildlife of Ethiopia as compared to the destruction of habitat (Bolton, 1972). In some regions of Ethiopia there are tribes that consider weapons as a priceless asset and reward a newly born male infant with a rifle. Thanks to the Ethiopian Revolution, a big programme is underway to embrace the once-neglected tribes and to encourage them to participate equally in the building of their nation and realise before hand the consequences of destroying habitat.

Prior to the establishment of a collection, a knowledge of ecological areas is of paramount importance. It is usually advisable, if possible, to perform a primary survey of a given region instead of a chance trial (for example, local inquiry). The initial survey should give some idea of the general volume of the collection. For this, a long-range plan is indispensable and should be associated with a stable programme. The drafting of the plan should be with interest and only dedicated individuals can accomplish this even if there are some setbacks. Putting the programme

only on paper just for the sake of temporary survival should be discouraged. In most cases, sacrifice is essential for future development of an institution. Sharing of experiences and exchange of views with different people or institutions either abroad or locally are very indispensable. One can gain the experience of others without committing grave mistakes or can use the same procedure with minor modifications if need be.

The other big obstacle is to get access to reference materials. The published papers on mammals are scattered and available mostly in specialised libraries. The only solution to this problem is to acquire the literature by a loan system according to the agreement of less payment with foreign institutions. This inadequacy of reference materials in a developing country like Ethiopia coupled with lack of specialists will add problems and force us to rely or depend upon alien help with minimal local experience. At the same time, the shortage of specialists has forced us to send specimens abroad with high mailing costs. The alternative method is to use the opportunity of getting help from different taxonomists who come to Ethiopia for a short-term visit. Many of the earlier collected specimens in Ethiopia have been stored in various museums of different countries. The type specimens are scattered making it difficult to obtain information on the taxonomy of many species. Establishing contact with various museums of different countries might minimise this problem. Shortage of trained personnel and experienced research staff have affected the management of organisation of the museum in addition to the difficulty of identifying local specimens.

Lack of funds has virtually curtailed organisation of collecting trips, buying and maintaining of collecting equipment and exhibit cases, and exchange of specimens. The Ethiopian fauna is very large, but as seen from the present collection, the museum has not gone far in fulfilling its aims (Tewolde and Beyene, 1981). Broadly, the aims of the Zoological Natural History Museum are to serve as a reference collection of Ethiopian animal species in cooperation with professional biologists interested to perform research on Ethiopian fauna, to produce scientific and popular publications on the Ethiopian fauna, and to provide zoological collections for teaching purposes and the public in general. People interested in performing research on Ethiopian fauna, except for birds and mammals, will not find reliable species-lists available. The museum at present harbours a very small collection (Afework and Shimelis, 1983). It is true that, compared with the much celebrated fauna of Ethiopia, a great deal of work should be done. The necessary infrastructure has not been laid. The local basis for rapid expansion has been weak because the development initially was based upon external inputs. It takes time to reverse this catastrophe and a long-range plan must be worked out. Although the door is open for collaborating foreign

researchers, the tight security and certain procedural clearances are not easily acceptable and so have created resentment.

Financial handicaps have not only acted as obstacles for the above mentioned points, they have also curtailed the expansion of space and the buying of chemicals and equipment indispensable for normal or smooth functioning to strengthen the limited collections. After failing to get sympathy with the concerned individuals, a project proposal was drafted to get international help. This draft, "Ethiopian Fauna Project Proposal", is being finalised and, if accepted, the implementation of it is expected to alleviate some of the most acute problems.

To store even the scarce collection, shortage of space was a problem. Through tortuous effort, the authorities were finally convinced that part of the old building should be allocated. This building initially was not meant for a museum. A museum building has to be built in a manner that is convenient for research personnel, storage, and public display. So, modification in a manner convenient for specimen display was carried out. Both the temperature and humidity content of the air have to be regulated to serve adequately for different seasons of the year. Lights have to be adjusted, otherwise the damage on the collected specimens will be very high in the long run and subsequent repairing can be a very laborious job. Use of high voltage light will shrink the displayed, and even the stored, specimens. Low voltage light will minimise the temperature creating a cold environment depending upon the season. Cold temperatures can easily dissolve certain chemicals like salt making big skins supple. The unusual contraction and relaxation of the skin of mounted specimens will result in breakage and damage. So, the room temperature of the museum should remain stable by using different light intensities based upon the season. Humidity is a much less important factor in Ethiopia except during the cold season and nights. In general, establishing and modifying of the rooms of a museum will further vary according to the region in the country.

For the proper organisation of collecting trips, proper chemicals and equipments are important. With the limited supply of funds, only certain chemicals can easily be obtained. In the absence of some chemicals like hydrogen peroxide in the preparation of skull mounts, the local method of using the powdered seeds of the *endod* plant (*Phytolacca dodecandra*) is more acceptable. Considering the large areas of Ethiopia over 1500 m above sea level, the plant has a wide distribution. It is both safe, quick-acting, and not as toxic as hydrogen peroxide. The seed can be used either dry or fresh. To overcome the shortage of facilities in the organisation of field collections for exhibits, we have managed to combine our field work with different institutions. This cooperation will minimise expense, but one has to adjust the programme according

to the timetable of the different institutions. Until the time comes when the museum becomes self-sufficient in expensive equipment, collections for exhibits that need heavy equipment are ignored. Photographs of big and whole specimens are pasted on the walls to compensate for the absent collections.

Another alternative was worked out to counteract obstacles faced because of the shortage of funds hindering the collections. The scheme consists of training graduating students on simple collecting methods and temporary storage practices. The museum at present is also used as a display center for mammals and other animals in the study of zoological courses. This will inculcate interest in the minds of the students. At present, the Department of Biology, Addis Abeba University, trains students to become mostly future high school biology teachers. Biological research institutions are highly limited in Ethiopia. About 90 percent of the graduating students in biology realise that they have to indulge themselves in the teaching profession. After the 1974 Ethiopian Revolution, high schools are proliferating in most regions of the governate-generals. This will mean the recruitment of additional teachers and the despatch of these graduated students to most regions of Ethiopia. Most of these teachers usually come to Addis Abeba at least once a year after the closure of the school. These teachers, if they have the interest and technique, can easily collect at least some specimens and temporarily store them using local containers if they take with them enough chemicals (formalin) prior to their departure. This programme, although lately established, is beginning to bear fruit at least in some regions of Ethiopia. In addition, more information can easily be obtained and brought to the museum on the distribution and abundance of species at different regions and seasons of the country. Through the accumulation of more information, it will be easier to arrange bigger expeditions at different times of the year depending upon the availability of funds for larger specimens. The other way of minimising cost is by arranging field trips with other institutions. The Ethiopian Wildlife Conservation Department is one of the main institutions that shows an interest in the preservation and collection of Ethiopian wildlife. In addition to providing information to the public, the institution can gain access to the museum and entertain different tourists as well. A plan is underway to facilitate this cooperation. In addition to this, most of the museum staff members are familiar with the wardens of different national parks. Some of these wardens have agreed to collect at least smaller specimens from their regions and thus add to the museum collections. Still another source of boosting collection is from foreigners that come to Ethiopia. Without some foreigners getting the necessary licenses, they illegally collect specimens and try to take the material with them from Ethiopia. At the check point of the airport, the specimens are confiscated, brought to the Wildlife Department, and finally end up in the museum. One

obvious disadvantage to this kind of collection is that the information on the card index will not be complete although collection sites can easily be identified.

Maintenance of the collected specimens was also a problem. As has been mentioned in the previous discussion, that due to shortage of money there is lack of storage space and cases. Part of the allocated rooms were modified and a large area was obtained by joining two adjacent rooms. Overcoming the shortage of space by trying to erect tukuls with minimum expense usually ends up in disaster. The experience shared by Buer (1971) in building a museum has given us a nice lesson. Because of the limited money, arrangements were made to erect a grass-roofed tukul using mud and an eucalyptus pole-frame. The specimens were displayed and stored in proper order. Unfortunately, this effort of building a small museum with little available money ended in disaster. Within a short time, termites consumed the eucalyptus pole-frame and passed to the grass-roof, showering their daily rains of dust, droppings, and themselves on the ground and part of the displayed specimens. This resulted in the laborious job of occasional cleaning and a shortening of the life-span of the collected specimens. The obvious alternative is to construct at least the base with a concrete barrier to keep the widespread and numerous varieties of voracious pests from entering the building, especially in lowland areas.

The attitude, interest, and behaviour of the taxidermists must be taken into consideration when establishing and maintaining the collected specimens. Experience reveals that although rushing may save time during the preparation of the skin or head mount, its long-term effect is to increase maintenance. If the taxidermist uses more programmed time initially and follows step-by-step instructions with minor modifications based on experience, the future job of maintaining the specimens will be eased.

For permanent storage, dressed skins of large mammals are hung on racks or walls in a well-ventilated room with low humidity. Fortunately, except during cold nights and the rainy season, humidity is not a problem at the present site of the museum building. Dust-proof cabinets with interchangeable drawers are used for storage of small and medium-sized mammal skins. Depending upon the varieties of shapes and sizes, dust-proof wooden cabinets can be built locally with minimal expense. Unless space is a problem, making, modifying, and repairing of these wooden cabinets is not difficult because of the availability of a carpentry shop in the institution. Unfortunately, these dust-proof wooden cabinets are not fire or vermin-resistant.



Small specimens are also stored in wet preparations of either alcohol or formalin in glass or plastic bottles with screw-on caps. These are available in different sizes and can easily be bought from the local market. In addition, some medium-sized glass or plastic bottles initially imported as containers for different purposes can be collected and reused with minimal expense as compared to the new ones. These reusable containers must be properly washed and cleaned to be used for storage purposes. These plastic or glass containers are preferable to metal ones in that they are rust-resistant when containing fluid preservatives of either alcohol or formalin. The supply of wooden shelves to keep the plastic containers is not a problem. However, the rooms are not fire-proof and are ill-ventilated. As long as the containers are well-sealed and kept in the dark, these specimens can be easily maintained for long periods.

In contrast to the wet preparation, dry materials, even if well-preserved and stored, are likely to be easily attacked by different pests. In addition to insect damage, moisture will also create an atmosphere conducive for growth of moulds (Wagstaffe and Fidler, 1968). Skins and head mounts of large mammals should be properly maintained by using different types of insecticides and fungicides. To maintain the collection, usage of a solid fumigant such as naphthalene flakes is recommended. The obvious disadvantage with naphthalene flakes is that it is highly flammable. Sometimes, only a temporary shortage of naphthalene flakes can cause extensive damage in the collected and stored dry specimens. We use local methods to maintain the dry collection in the absence of naphthalene flakes. This local method is to fumigate the room containing the collected specimens by using the resins of either *Boswellia* spp. or *Commiphora* spp. Both these plants are widespread in low-land areas of most regions of Ethiopia and the resins can easily be collected from the wild habitat or purchased in the local markets. However, the resins should be used only occasionally and the frequent use might result in a disadvantage. The odour of the fumigant might not be pleasant for some individuals and might stay too long especially if the room is not properly ventilated. In addition, continuous and frequent fumigation with these resins will, in time, leave some of the resins attached to exposed areas of the display or storage cases thereby attracting dust. Because of the above disadvantages, these resins should only be used as a temporary solution during shortages of other insecticides to properly protect the collected specimens in the museum from insect pests.

#### SUMMARY

Despite the unique and diverse fauna of Ethiopia, a negligible amount of collecting has been carried out by different mammalogists. The inadequacy of the transport system, topographical features of the

country, people's traditions, lack of trained manpower with knowledge of the ecological areas and extant collections, shortage of space, and lack of sufficient finances for buying proper equipment are discussed as some of the main problems faced in starting a new collection. As an alternative simple training of graduating biologists as collectors is stressed as a means to cover most regions of Ethiopia with minimal expense. The use of powdered seed of the *endod* plant (*Phytolacca dodecandra*) to compensate for the shortage of chemicals for the field preparation of skulls is recommended. Modifications of space for the museum depending upon the season and region, in addition to various specimen preparation procedures are discussed as well. Cooperation with other governmental institutions, long range planning, and exchange of experiences are outlined. Local methods of maintaining the specimen collections in the absence of naphthalene flakes *i.e.* the use of the resins of the plants *Boswellia* spp. or *Commiphora* spp. are introduced as alternative insecticides.

## REFERENCES

- AFEWORK BEKELE and SHIMELIS BEYENE. 1983. *Checklist of the Ethiopian mammal fauna present in the Zoological Natural History Museum*. Typescript, Boil. Dep., Addis Abeba Univ. Pp. 1-31
- ALLEN, G. M. 1939. A checklist of African mammals. *Bull. Mus. comp. Zool. Harv.*, **8** : 1-763.
- BLOWER, J. 1969. Wildlife conservation in Ethiopia. *Walia*, **1** : 15-23.
- BOLTON, M. 1972. Report on a wildlife survey of southeast Ethiopia. *Walia*, **4** : 19-31.
- BROWN, L. H. 1973. *Conservation for survival, Ethiopia's choice* : 1-96. Haile Selassie I Univ., United Printers Ltd., Addis Abeba.
- BROWN, L. H. and URBAN, E. K. 1970. Bird and mammal observations from the forests of southwest Ethiopia. *Walia*, **2** : 13-40.
- BUER, C. 1971. Building a museum, the Awash National Park Museum and information room. *Walia*, **3** : 12-18.
- DANIEL GAMACHU. 1969. *The location and topography of Ethiopia* : 1-70. Haile Selassie I University, Addis Abeba, mimeographed.
- DELANEY, M. J. and HAPPOLD, D. C. D. 1979. *Ecology of African mammals* : viii + 1-434. Longman Group Limited, London.

- HALTENORTH, T and DILLER, H. 1980. *A field guide to the mammals of Africa including Madagascar* : 1-400. William Collins & Co. Ltd., Glasgow.
- KINGDON, J. 1971 *East African mammals : an atlas of evolution in Africa*. Vol. 1 : x+1-446. Academic Press, London.
- LARGEN, M. J. 1969. A report on the present status of the Natural History Museum. *Walia*, **1** : 38-45.
- LARGEN, M. J., KOCK, D. and YALDEN, D. W 1974. Catalogue of the mammals of Ethiopia. 1 Chiroptera. *Monitore zool. ital. (N. S.) Suppl.*, **5** : 221-298.
- MATHEWS, R. 1977. *Report of the 1974 west Ethiopia scientific expedition* : xiii+1-202. The Polytechnic of Central London Exploration Society, London.
- MESFIN, W. M. 1970. *An atlas of Ethiopia* : 1-84. Poligrafico Private Ltd. Co., Asmara, Ethiopia.
- MORRIS, P. 1968. The great Abay expedition : iv+1-262. Crown copyright, London.
- SCOTT, H. 1958. Biogeographical research in High Simien (Northern Ethiopia). *Proc. Linn. Soc. Lond.*, **170** : 1-91.
- TEWOLDE BERHAN, G. E. 1972. Soil conservation in Ethiopia. *Walia*, **4** : 32-38.
- TEWOLDE BERHAN, G. E. and BEYENE PETROS. 1981 Biological Sciences Museums in Ethiopia. Report on "Workshop on Natural Sciences Museums" Nairobi, Kenya, typescript, 21 pp.
- THOMAS, O. 1903. On a collection of mammals from Abyssinia, including some from Lake Tana, collected by Mr. Edward Degen. *Proc. Zool. Soc. Lond.*, **2** : 308-316.
- THOMAS, O. 1928. Some rarities from Abyssinia with the description of a new mole-rat (*Tachyoryctes*), and a new *Arvicanthis*. *Ann. Mag. nat. Hist.*, **1** (10) : 302-304.
- WAGSTAFFE, R. and FIDLER, J. H. 1968. *The preservation of natural history specimens*. Vol. 2 : xv+1-404. The Brodwater Press Ltd., London.

- WALKER, E. P. 1975. *Mammals of the world*. Vol. 2. (3rd ed.) : xlviii + 1-644. The John Hopkins University Press, Baltimore & London.
- YALDEN, D. W. 1983. The extent of high ground in Ethiopia compared to the rest of Africa. *Sinet*, **6** (1) : 35-39.
- YALDEN, D. W., LARGEN, M. J. and KOCK, D. 1976. Catalogue of the mammals of Ethiopia. 2, Insectivora and Rodentia. *Monitore zool. ital. (N. S.) Suppl.*, **8** : 1-118.
- YALDEN, D. W., LARGEN, M. J. and KOCK, D. 1977. Catalogue of the mammals of Ethiopia. 3. Primates. *Monitore zool. ital. (N. S.) Suppl.*, **9** : 1-52.
- YALDEN, D. W., LARGEN, M. J. and KOCK, D. 1980. Catalogue of the mammals of Ethiopia. 4. Carnivora. *Monitore zool. ital. (N. S.) Suppl.*, **13** : 169-172.

#### DISCUSSION

- Q. *Whether any study has been carried out to ensure that there will be no interaction of different locally made plant-products with the specimens in near future ?*
- A. So far, practically no study has been carried out. Probably future work might reveal some side effects. Observations are being made on the effect of these plant-products on the specimens.



## STARTING A NEW MAMMAL COLLECTION

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Study of preserved specimens of mammals as an important way of understanding animal life has various applications. They range from those of a study collection for a museum to those of the odd specimen or two, or of a small collection of one or more species that is often the by-product of some ecological or anatomical investigation of an individual scientist. The latter category might also involve collections of broader scope such as those made as a faunal inventory for ecological studies of a locality, or random series of age, sex, species, comparing several localities, or large series of a population to study individual variation. Or it may also be done to delineate the distribution of a species or to assess the status of a rare or endangered species, although the latter must be done with extreme circumspection. However, many or all of these objectives could overlap with those of museum collections. In fact, a modern scientific collection of study specimens in a museum, if systematically done with proper prior planning and recognition of principles, could serve multiple functions, as mentioned above, besides taxonomic studies. It is, therefore, the broad principles for general collecting and preservation of mammal specimens for museum, and similar organisations desiring to establish or augment large collections for faunistic studies that are mainly dealt with here.

### MUSEUM STUDY COLLECTIONS

Museum study collections should serve at least the following main functions (Fig. 1) :

1. To serve as a reference collection in identification of species
2. To facilitate taxonomical research especially in :
  - (a) recognition of species
  - (b) developing hierarchy
3. As authentic evidence for distribution of fauna
4. To extend the understanding of evolutionary mechanisms
5. To provide important body-organ parts for further morphological or anatomical elucidation (like skulls, teeth, bacula, key internal organs, etc.)
6. To provide exhibits.

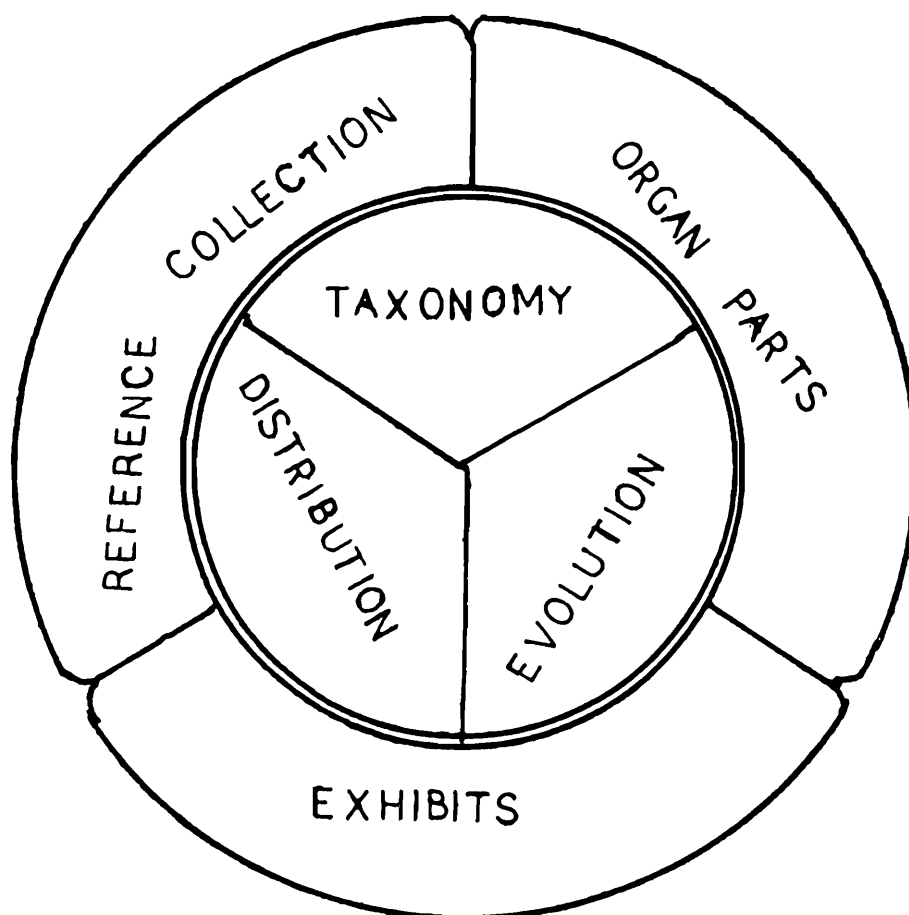


Fig. 1.—Main functions of museum collections. These encompass core functions of elucidating taxonomical, evolutionary and distributional issues. Others form encore or additional functions like serving as reference collection and exhibits and for supplying organ-parts for other researches.

The first function as a reference collection, although of immediate utility and facility value, is actually the end result of serving all other functions, and a deductive synthesis of all information gained in the process. In this sense, the basic functional core of museum collections could be seen to centre around the second, third and fourth of those mentioned above i.e. : resolving the taxonomical, distributional and evolutionary issues of the taxa concerned. Others are in the nature of additional functions.

While a new mammal collection should be planned for producing material that ultimately serves all above functions with the immediate objectives, towards these core functions.

#### MAMMAL COLLECTION

Mammal collections can be broadly considered under two categories.  
1 Macro-species collections, 2. Micro-species collections.

##### *Macro-Species Collections*

Macro-species collections are now largely done only for museum exhibits or to fill the gaps in the existing collections as it involves large

mammals whose taxonomy might be fairly well settled, and whose populations in most of the cases are under severe biological or environmental limiting factors. However there are still some large mammal species whose taxonomic status especially at the infra specific level, are not yet clear. Limited collections in this respect are, therefore, still necessary.

While planning for macro-species collecting the preliminary phase includes :

1. Preparation of a gazetteer of known distribution localities
2. Gazetteer-updating through questionnaires to Forest/Wildlife Departments
3. Preparing a dossier of basic information on ecological factors like endangered status, breeding season, pinch period, antler shedding, etc. This would be necessary for specific purposes such as obtaining young specimens, family group, males with good antlers in or out of velvet, ease of collecting, etc.
4. Obtaining shooting or trapping permits, information on closed periods or areas, and collaboration arrangements with forest authorities.

If the purpose is to install habitat groups or diaramas, the ideal thing is to collect enough specimens of a species reflecting its family, harem, troop, or herd structure as the case may be. However, this is often not possible, and if so, while an adult male and female would be the bare minimum, obtaining additionally a young, and if possible, an adolescent would suffice for the purpose. However, it should also be borne in mind that collecting large mammals is strictly subject to their conservation status and objectives.

#### *Micro-species collection*

For studying collections of museums, it is the micro-species or small mammal species that are of most importance and interest. Here the concept of series-collecting becomes valuable in meeting the core objectives mentioned earlier. A series-collection containing specimens representative of all populations for the entire distributional range of the species that is also representative of the age, sex, and seasonal variation and if collected in large numbers to reflect individual variation also, becomes just about the most ideal series-collection of species (Fig. 2). However, this is seldom a practicable proposition, except in case of abundant common species or those considered pests for which eradication programmes are launched (eg. rodent pests). Development of such a series might be possible over a length of time in the case of some sub-common species also, but is out of the question in rare, restricted, or ecologically specialised forms.



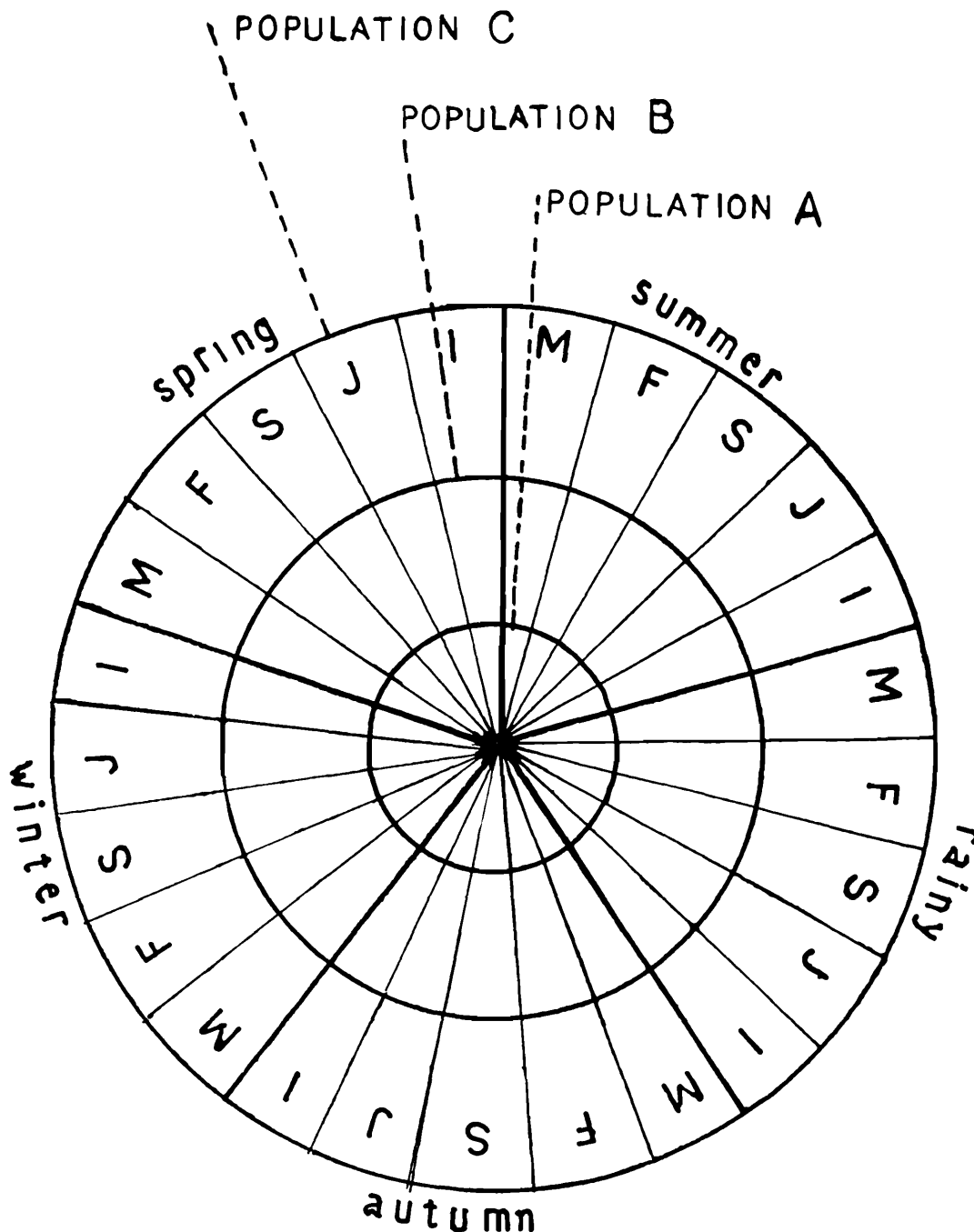


Fig. 2.—The ideal series collection. The series should ideally contain samples of each population (A, B, C etc) of a species in the total range of its distribution consisting of all age-sex classes and of specimens collected in all seasons in the region of distribution. M, F, S, J, I :—Male, female, subadult, juvenile and infant classes.

However, for most of the small mammal species, a limited number of specimens from each of the ecologically different areas collectively representative of its, entire geographical range, randomly collected to include all age-sex classes and properly spaced in season would be an adequate compromise and should serve most of the objectives. In certain problematic cases further collecting could always be attempted according to the facets of the problem. In museums all over the world there is a general shift from broad purpose expeditions to those for intensive collecting of specific groups, families, or genera (Mayr, 1969). For example, Lynes' study of the bird genus *Cisticola*, through collecting trips to every

part of Africa, which not only settled problematic taxonomy of the genus but also resulted in detailed studies of its ecology and behaviour (Lynes, 1930).

#### GEOGRAPHIC, GENETIC VARIATION

Taxonomists now tend to view biological classification as the ordering of populations (Mayr, 1969), and collecting, therefore, is sampling the populations. The species problem is fundamentally a genetic problem and the genetical question is intimately involved in many problems of systematics such as morphogenesis, variation, isolation and the like (Simpson, 1961). A number of recent studies bring out clearly the importance of series collecting in not only understanding taxonomical status of a taxon but also providing much insight into evolutionary mechanism operating in populations.

A number of rodent and shrew species are shown to be polymorphic in their chromosome structure (Meylan, 1970 ; Ford and Hamilton, 1970), sometimes leading to well known case of sibling or crypto species with phenotypically unmanifest genetic differences.

Works of Semenoff and Robertson (1968) and Mc Dougall and Lowe (1968) revealed the existence of "biochemically polymorphic species like short-tailed vole where allelomorph frequency changed with the cycle of population number, or of red deer populations showing frequency change geographically from east to west. Sometimes pointers thrown out by ecological studies could be further confirmed through series-collection. For example, Stoddart (1970) shows that female water vole after one reproductive season moves long distances to establish another range in another colony in time for the next breeding, whereas the male is confined to the original site. This indicates that a genetic variant can spread rapidly in a population independent of environmental or geographic factors and so also any disease in this population. Similarly house mice in Britain tend to segregate into a resident population in granaries and a roamer population in the vicinity outside, each evolving different gene frequencies, and also genetic isolation between resident demes in a region leading to genetic differentiation through inbreeding. (Anderson, 1970 ; Berry, 1970).

#### DISTRIBUTION, DISPERSAL

Distributional records provided by collections is the most authentic source of information on the distributional range of a species both in the past and in the present. With the general trend of shrinkage of most mammal habitats, collected specimens become invaluable evidence for the type of populations that existed in an area from where it has since disappeared.

In addition, exact knowledge of the distributional periphery of a species is very important as it is at this peripheral zone that geographical isolates and incipient new species form frequently (Mayr, 1969). It is particularly important in case of species of uncertain status to determine their pattern of distribution in respect of allopatry or sympatry.

In allopatric populations, collecting should be done in intervening regions also, to look for intergradation (Mayr, 1969). Importance of data on spatial distribution in classification of species and subspecies is shown in more detail by Mayr (1942) and in higher taxa by Darlington (1957). In this connection Simpson (1961) points out that data on spatial distribution not only place animals with precision in local populations but also more broadly in a zoogeographic frame work.

Sometimes series collecting will be instrumental in understanding the dispersal source of populations as in the case of British wood mouse. Its various island populations while differing among themselves in skull characters, collectively show an affinity not with the mainland British form, but to the distant Scandinavian stock, suggesting their direct introduction by the Vikings in the first millennium A.D. (Berry, 1970).

#### COLLECTION OF ECOLOGICAL INFORMATION

Mammal collections are also opportunities for collecting much associated information. In keeping with the approach of mammal collecting as a sampling of the population, sampling is best done at random and unbiased to that it would reflect the age and sex class structure of a population. The mammal collector can also enhance the value of his collection and field work, with film and sound recordings and observations of the behavioural ecology of the species along with samples of associated parasites and artifacts of the animal itself such as nests, casts of tracks, etc.

Breeding period is a particularly opportune time to collect information on a significant part of the behavioural repertoire of the species. A modern mammal collector's field diary (Fig. 3) should contain detailed notes on all these aspects. Both synecology and behaviour are increasingly used as tools in a comprehensive approach to taxonomical research and according to Simpson (1961) synecology is even a part of taxonomy.

Similarly, a mammal collecting trip is an unrivalled opportunity, to procure material at a range and level for many associated histological, anatomical, and genetical work. Sample specimens of whole bodies after skinning could be wet-preserved and wherever not feasible owing to size,

FIELD DIARY		G.U. Kurup
3 December 1981	Locality: Agali, Attapadi Hills, Palaghat Dist. Kerala ca. 500 m. m.s.l. station no. 1. Ca 6 km on Mannarghat Rd.	
○ Habitat	Moist deciduous forest area with a cleared patch on one side and a stream on the other some new settlements near by	
○ Trapping	6 Sherman, 6 country cage type and 6 break-neck traps set along stream bank and in the clearing 5.30 to 6 p.m. Bait: Coconut & Pea- nut butter. Catch collected 9.30 pm. Reset	
○ Observations	Observed one <u>Ratufa indica</u> near stream, feeding on <u>Salmalia</u> blossom. Uttered two shrill notes during 15 minutes watched. Shot and collected. Pug marks of leopard observed in the dried muddy bed of stream. Bonnet monkey troop of ca 18 members among the road side trees	
○ Collections	Trapping: " Coll. No. 355 } <u>Rattus rattus</u> 2 ♂, 3 ♀ to 359 } (2 Sherman, 3 country) " 360 } <u>Bandicota benghalensis</u> , 2 ♂ 361 } (country)	

Fig. 3.—Sample page of a Mammal collectors' Field Diary.

etc., care should be taken to preserve important internal organs in appropriate fixing and preserving chemicals.

### TRAPPING

It is not intended here to go into the details of field techniques of collecting and also preservation of animals, as there are a good number of books already on the subject and also, no doubt, there are going to be many contributions in this seminar itself devoted to this main subject. However, because trapping is by far the most important field technique in micro-species and series-collecting, principles of trapping that are relevant in the approach so far outlined above may also be briefly discussed.

As already mentioned, in most of the broad range mammal collections of a region or group, the objective should be to obtain a random sample of the populations involved. Trapping should be designed for this. There are two basic types of trapping : free trapping and bait-trapping. Bait-trapping introduces a problem of sample bias, as many mammal species are either trap-shy or trap-prone. The problem can be somewhat allayed by prebaiting, but not fully. As far as possible, therefore, free baiting is to be preferred when random sampling is critical. Once a collection is made from an area there should not be any further selective trapping to make the collection ostensible representative.

If the objective, however, is merely to collect specimens, the collector should see that the catch may not be heavily dominated by one or two abundant species, that will lessen the intensity of trapping less common species. Also quicker methods of preservation may be used for common species so that more time is available for collecting scarcer species.

A number of factors which affect trapping success have been reviewed by Kikkawa (1964). Most important of these are the types of baits used, physical and weather factors, structure and composition of the habitat, availability of food, and type of traps and their deployment. Deployment with regard to site, number of traps at points, spacing, and pattern (line or grid) are all particularly important. As a rule, the number of traps at each trapping point should be sufficiently high and in bait-trapping at least about 20 % of the traps could be left empty. Intertrap distance might vary according to habitat or species, but about 15 m could be considered as standard for common species but random spacing is to be adopted if the data have to be treated statistically.

### NATIONAL MAMMAL SURVEY

It is almost half a century since the nationwide collecting of mammals initiated by the British Museum of Natural History contribute

so much to Indian mammalogy. Though Zoological Survey of India and other agencies have been continuing to conduct mammal collecting in various areas in the country, there had not been any co-ordinated nation-wide mammal survey since then. The exponential expansion of human population settlements, and other faunal decimating factors during the last half century need no elaboration. As a class, perhaps mammals are the most threatened and whose habitats and therefore the distributional range shrunk enormously. There is an urgent need for collecting specimens of many species and populations before they disappear. There is also an equal urgency to collect information on the current distribution and status of all mammal species so that distributional maps for each of them could be prepared as the most essential input for designing a conservation strategy. Exact distributional maps are now available only for very few species (Kurup, 1978, 1980, for primates in S. India). Such mammal collecting and status survey should be essential components of National Environment and Wildlife conservation strategy.

#### SUMMARY

A modern scientific collection of mammals in a museum, if systematically done with proper prior planning and recognition of principles could serve multiple functions besides taxonomic studies. The basic functional core of museum collections could be seen to centre around taxonomical research especially in recognition of species and developing hierarchy, as authentic evidence of faunal distribution and to reveal the evolutionary mechanism. Mammal collection falls broadly under two categories namely, macro-species collection and micro-species collection. The former should include preparation of a gazetteer of known localities, dossier on ecological factors like endangered status, breeding season, pinch period, antler shedding, etc. However, collecting large mammals is strictly subject to their conservation status and objectives. Macro-species collection, is of importance and interest, made on series-collection including representative of all populations of the entire distributional range with age, sex and seasonal variation data. Species problem is fundamentally a genetic problem in relation to morphogenus variation, isolation and the like.

Series-collection becomes invaluable evidences to determine the past distribution of a disappeared species from the area and understanding the dispersal source. Knowledge about the distributional periphery of a species is very important since the geographical isolates and incipient new species emanate frequently at the peripheral zone. Synecology and behaviour are increasingly used as tools in a comprehensive approach to taxonomy. Mammal collection procured at range and level can be utilised for associate histological, anatomical

and genetic works. Free-trapping is to be preferred to bait-trapping for collection. There is urgent need for collecting selective specimens before they disappear and to collect information for designing conservation strategy.

As an essential component of National Environment and Wildlife conservation strategy, a National Mammal Survey is proposed to be carried out on 50 km geographical grid (roughly corresponding to the medium-sized districts of our states), system. Proposed surveys could be conducted by the existing regional establishments of the Zoological Survey of India.

#### REFERENCES

- ANDERSON, P. K. 1970. Ecological structure and gene flow in small mammals. *Symp. zool. Soc. Lond.*, **26** : 299-325.
- BERRY, R. J. 1970. Covert and overt variation, as exemplified by British mouse populations. *Symp. zool. Soc. Lond.*, **26** : 3-26.
- CORBET, G. B. and SOUTHERN, H. N. 1977. *The Handbook of British Mammals*. Blackwell Scientific Publications, Oxford.
- DARLINGTON, P. J. 1957. *Zoogeography : The Geographical Distribution of animals*. New York.
- FORD, C. E. and Hamilton, J. L. 1970. Chromosome Polymorphism in the common shrew, *Sorex araneus*. *Symp. zool. Soc. Lond.*, **26** : 223-36.
- KIKKAWA, J. 1964. Movement, activity and distribution of the small rodents *Clethrionomys glareolus* and *Apodemus sylvaticus* in woodland. *J. Anim. Ecol.*, **33** : 259-299.
- KURUP, G. U. 1978. Distribution, habitat, and status survey of the lion tailed macaque, *Macaca silenus*. *J. Bombay nat. Hist. Soc.*, **75**(2) : 321-340.
- KURUP, G. U. 1980. Report on the Census surveys of Rural and Urban Populations of Non human Primates of South India. Mimeographed Report. Zoological Survey of India, Western Ghat Regional Station, Calicut-6.
- LYNES, H. 1930. Review of the genus *Cisticola*. *Ibis* (suppl.), 673 pp.

- MAYR, E. 1942. *Systematics and the Origin of Species from the viewpoint of a Zoologist*. Columbia University Press, New York.
- MAYR, E. 1969. *Principles of systematic Zoology*. McGraw-Hill, New York.
- MC DOUGAL, E. I. and LOWE, V. P. W. 1968. Transferrin polymorphism and serum proteins of some British deer. *J. Zool., Lond.*, **155** : 131-140.
- MEYLAN, A. 1970. Chromosomal Polymorphism in mammals. *Symp. zool. Soc. Lond.*, **26** : 211-22.
- SEMENOFF, R. and ROBERTSON, F. W. 1968. A biochemical and ecological study of plasma esterase polymorphism in natural populations of the field vole, *Microtus agrestis* L. *Biochem. Genet.*, **1** : 205-27
- SIMPSON, G. G. 1961. *Principles of Animal Taxonomy*. Columbia University, New York.
- STODDART, D. M. 1972. The lateral scent organs of *Aravicola terrestris* (Rodentia : Microtinae). *J. Zool. Lond.*, **166** : 49-54.

#### DISCUSSION

- Q. *Can you elaborate your point "Quicker methods of preservations should be used for common species in order to devote more time for rare animals" ?*
- A. In simple terms, after preparing first few specimens of a species as study skins, the rest of the specimens caught in traps, etc. could be wet-preserved in liquid preservatives which is a quicker method. The time thus saved could be utilised for looking for and collecting relatively rarer or trap-shy species.
- Q. *What should be the standard sample-size for the museum collection of a species expressing variations at a gene level ?*
- A. Standard number might vary according to species, their conservation status, and objectives of collection. A minimum could be about 20 specimens of the genetical variants when statistical 't' test could be applied. However, if mere collection is involved four specimens from each population might suffice as far as small mammals are concerned.





## **PROBLEMS OF MAINTAINING A LARGE COLLECTION OF MAMMALS IN A DEVELOPING NATION : NATIONAL MUSEUM OF ZIMBABWE**

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Every museum has its problems. Often the problems will be similar to those of other museums, but are caused by different combinations of factors. This paper will attempt to look at some of those problems, their causes and their solutions in the National Museum, Bulawayo, Zimbabwe.

### **DEALING WITH ISOLATION**

Zimbabwe is a land-locked country in southern, central Africa. Bulawayo is the second largest city in Zimbabwe (population approx. 400,000), and is some 480 kms southwest of the capital city, Harare (Fig. 1). Although there is an international airport at Bulawayo, the majority of international airlines fly directly to Harare, thus the foreign visitor must make a further journey in order to reach Bulawayo. This means that Bulawayo is a somewhat remote location for a major Natural History Museum, and this isolation has contributed in many ways to the problems experienced in the past, and will continue to contribute to problems to be faced in the future.

A direct result of isolation is that, although the mammal collection is significant in terms of its size and scope (Jones, 1985 ; Genoways and Schlitter, 1981), it is seldom visited by foreign scientists. As a result of difficulties in loaning specimens outside Zimbabwe due to both the unreliability of the postal system and the stringent customs regulations of numerous countries, the collections are vastly underutilised, poorly known, and often ignored. Thus little interest (until very recently) has been shown in the collection by the international community.

Lack of funding within the organisation in Zimbabwe has contributed to the problem of isolation as national personnel have had few opportunities to travel during the last fifteen years, and therefore have lacked the personal contacts with colleagues from other countries which

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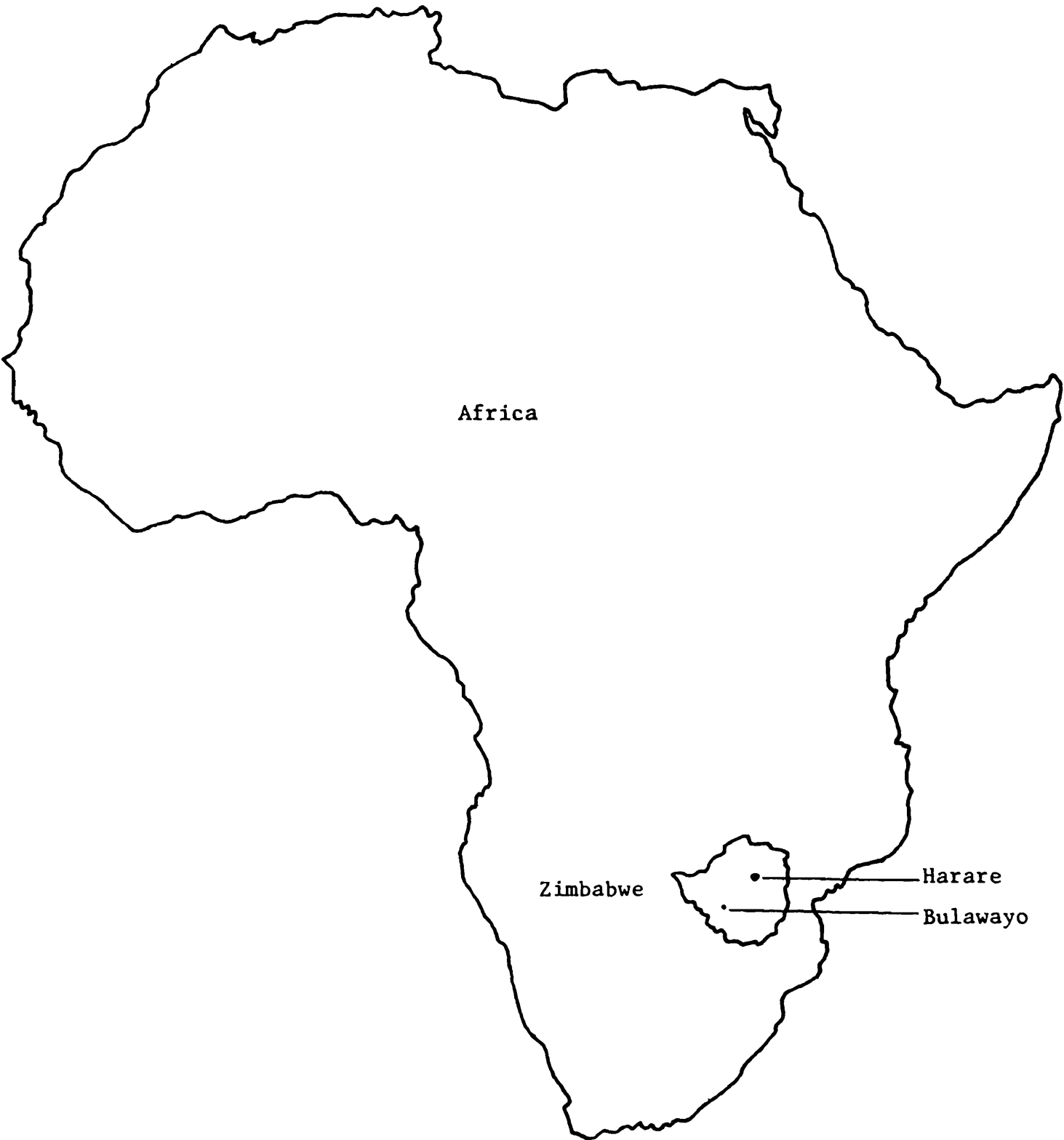


Fig. 1.—Map of Africa showing location of Zimbabwe, Harare and Bulawayo.

are so important in the development of ideas and in keeping others informed about the collections.

This is a familiar story in many developing nations and has important effects on the management of their collections. In order to properly comprehend the importance of maintaining existing collections in as perfect a state as possible, it is necessary for curators and their curatorial assistants to see other museums, talk with other personnel, and in this way obtain first-hand experience of well ordered collections. This also permits diffusion of new ideas. In addition, it is important for curatorial assistants to understand the nature and importance of the scientific research which is based on the collections in their care. This understanding provides the basis for motivation to insure that collections are properly maintained.

These problems have been recognised by many of the major museums in the developed world, and directors of third-world museums should be encouraged to find out about, and to utilise the programmes offered by these museums. It should be stressed that the programmes and internships are not open to post-graduate students only. There are openings for technical workers, providing opportunities for practical experience, and often funding is available.

#### THE COLLECTION

The collection of mammals in the National Museum, Bulawayo, is very large (above 80,000 specimens) and comprises several kinds of collections, each with its own problems in preparation and storage. Problems associated with the collections of large mammal hides, skeletons, and the small collection of spoor casts and scats were discussed in a previous paper (Jones, in press). This paper will attempt to deal generally with each of the other collections, describing field techniques, preparation techniques, and storage.

##### *Small Mammals*

The collection of small mammals is divided into two sections : the standard study skin and skull collection, and the "wet" collection. All small rodents and insectivores are prepared as dry specimens and stored in drawers in standard, ten drawer, wooden cabinets. The drawers are constructed from a lightweight wood with a hardboard base. They were lined with a thin layer of foam rubber to prevent specimens from rolling, and to protect the specimens from direct contact with the hardboard. When foam rubber became unobtainable, blotting-paper was substituted. A wooden bar is placed across the width of the drawer, towards the front, to keep the skull vials in place (Fig. 2).

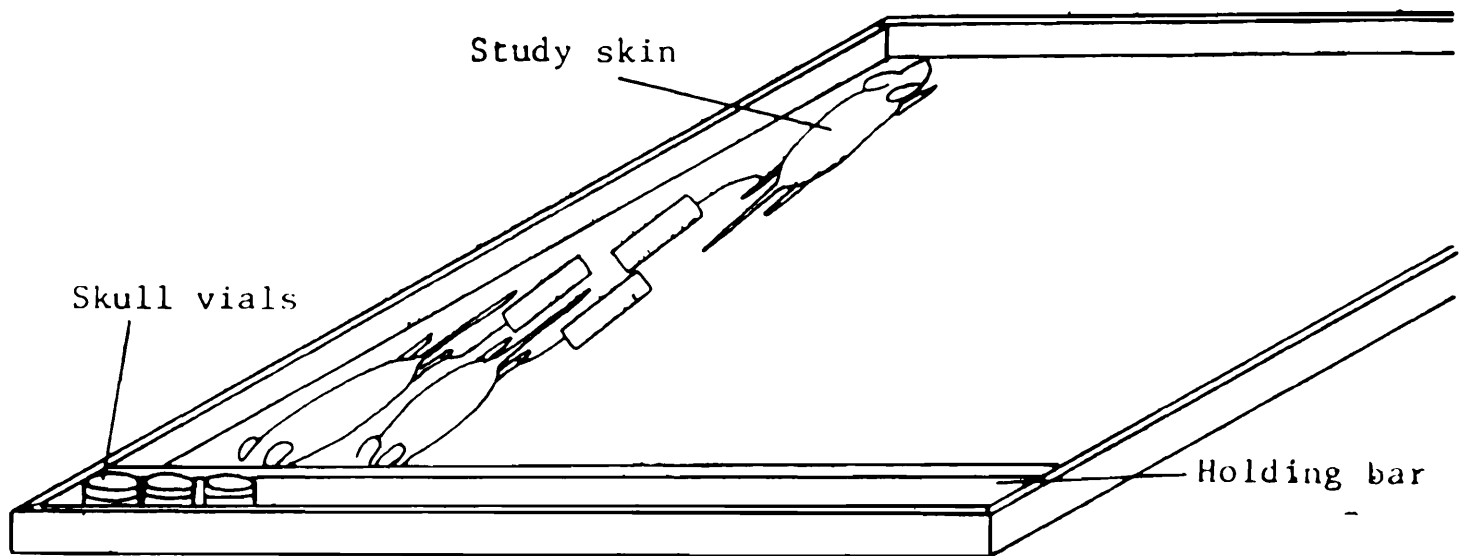


Fig. 2.—Small mammal storage showing positions of skull vials, wooden holding bar, and study skins in each drawer.

Skull vials are standard, plastic, tablet containers with plastic lids. Glass vials, when obtainable, are prohibitively expensive.

All new chiropteran material is stored wet in glass jars. There is also a substantial collection of dry skins and skulls. Skins are prepared in the standard fashion ; however, due to the ever-present threat of insect attack, extra precautions to discourage insect activity are taken. During the skinning process corn meal is not used, but substituted with heavy magnesium carbonate as a dusting powder. A mixture of 5lb powdered borax, 1lb sodium silicofluoride and 4 tablespoons purified creosote (Smithers, 1973) is used as a preservative and insecticidal powder which is rubbed into the inside surface of the cleaned skin, and the insides of the feet and ears. The borax is a mild insecticide and insect repellent ; the sodium silicofluoride and creosote are both preserving agents and insecticides. This procedure has been used for over twenty years, and no deleterious effects have been noted either on the specimens or in museum personnel. In addition, although there are no figures to support this statement, the problems of insect invasion within the collection seem to be of a smaller magnitude than in many other collections.

Field techniques have been developed to cope with both the problems of live trapping and prevention of insect attack. Due to the unavailability of standard Sherman traps, K. M. Adams (curator of mammals, 1978) designed an efficient live trap, using locally available materials (see appendix).

Although these traps are relatively heavy and cumbersome, and do not collapse, they have several advantages. First, cotton waste is placed in the back of the trap so the inmate can more easily survive a sojourn in the trap in extreme temperatures. Both the wood and the cotton act as insulators against heat and cold. Second, the back of the trap is removable, which makes it both easier to see what is inside, and to shake the animal out into a bag.

Field preparation of specimens is carried out in a slightly different manner than preparation in the museum as a further precaution against insect attack. Uncleaned skulls are treated with the borax/creosote/sodium fluosilicate mixture, and naphthalene is liberally introduced into all the drying trunks containing skins. Field collections are fumigated with triple quantities of Vapona on arrival at the museum before being allowed into the building.

Until recently, all skull and skeleton cleaning was carried out by hand. Skulls were boiled in a solution of sodium perborate and water, scraped clean, soaked in a saturated solution of sodium fluosilicate, and sun dried. However, with the recent experimentation with a *Dermestes* colony for cleaning skull and skeletal material, the treatment of these parts in the field has changed. Skull and skeletal material is no longer treated with the insecticidal mixture described above, but simply dried and kept separate from the drying skins.

### *Wet Collection*

In 1979, a major policy decision concerning the preparation of chiropteran material was made. It was decided that, in the future, all chiropteran material would be stored in fluid. Although it is agreed that working with fluid-preserved specimens is unpleasant and possibly deleterious to the health of those working with the specimens, the material suffers a great deal less from the distortion so obvious in dried specimens. Stored wet, nose-leaves maintain their characteristic shapes (important in the rhinolophids which often can only be identified in the field by their nose leaves). Lip shape in molossids is preserved. In addition, the whole animal is preserved for various types of possible future research. Skulls can easily be pulled from wet specimens and masks can be worn to protect those handling the specimens.

Specimens are fixed for two weeks in 10% formalin buffered with hexamine (Smith, 1947). They are stored in 5% formalin buffered with hexamine to prevent decalcification, with a drop of glycerine added to each jar to keep membranes supple. During the 1970's, the entire wet collection of bats was transferred from 10% formalin to a 40% solution of Isopropanol following the successful use of this preservative in the

National Museum's Ichthyology collection. In 1980, however, it was discovered that the wing membranes of the chiropteran material were becoming brittle and tearing easily, and so, gradually the specimens are being transferred back to formalin, but at 5%. The major part of the national collection of Herpetological material has been stored in 5% formalin for at least twenty years (Broadley, pers. comm.) with no apparent deleterious effects. Thus, it was decided to follow this example with careful, regular monitoring of the situation.

The collections of rodents, stomach contents, reproductive organs, and foetuses are stored in either 10% buffered formalin or 40% Isopropanol, both of which work well for those types of specimens.

The problem with obtaining suitable glass jars became acute in 1982 for all departments. Wide-mouth jars are difficult to find in Zimbabwe and are expensive. However, surprisingly, the problem proved very inexpensive and quite simple to solve. An advertisement was inserted in the local newspaper, appealing to householders to donate empty jars with lids. The response was overwhelming. One member of the staff spent two weeks sorting jars, and we now have several years supply.

The problem with lids, however, appears insurmountable. It is no longer possible, in Africa at least, to purchase ball jars with glass lids. The new jars are provided with metal lids. Metal lids of all kinds rust rapidly, especially when in contact with formalin fumes, and often do not seal well. Coating the inside surface of the lid and the threads at the top of the jars with vaseline works well as a sealant, and provides some protection to the metal from the corrosive effects of the preserving liquids. The lids, however, will require replacing in time. Bakelite lids do not seal well, though again vaseline acts as a remarkable good sealant. In addition, they eventually become brittle and crack or disintegrate. Until such time as an inexpensive, tightly fitting, rust-proof, lasting lid becomes available in the market, the museum worker must resign himself to having to inspect and replace lids from time to time.

Jars are stored on wooden shelving. According to the Chief Fire Officer, Bulawayo, it is preferable to store flammable liquids in glass jars on strong, wooden shelving, as metal shelving tends to buckle in fire situations, throwing the glass containers onto the floor where they will burst.

### *Medium-sized Mammals*

Medium-sized mammals were prepared as standard, round skins with skulls until storage space became a major problem. As the National

Museum has its own tannery, which runs relatively inexpensively, it was decided to tan medium-sized mammal skins and store them in standard cabinets as flat skins. This procedure applies to both incoming specimens and old, already prepared specimens. Fresh skins are salted with fine, dairy salt, dried, and stored until they can be incorporated into a tanning run. Old specimens are relaxed, the stuffing is removed, and then they are tanned very successfully, provided the skinning was carried out carefully in the first place and the skins have not been damaged by fat burn. This system, as well as alleviating the space problem, also affords the skins a good measure of protection against insect attack.

### INSECT CONTROL

The National Museum has not, in recent years, experienced major problems with insect infestation in the collections. This is due to careful habits and constant monitoring of the collections.

Firstly, the chemicals used in the preparation of specimens have contributed towards the deterrence of insect activity. Secondly, the collections are inspected regularly; drawers are removed from cabinets, all the specimens therein removed and carefully dusted with a paintbrush; the drawer is cleaned and the specimens replaced. This procedure is carried out whenever any member of the staff has a few moments to spare. Napthalene was, until recently, placed as a repellent in each cabinet on a regular basis, and any infestation discovered was dealt with immediately, using various fumigants ranging from Gammatox to Paradichlorobenzene. All incoming specimens were fumigated prior to introduction into the collection, and were inspected visually for signs of insect activity.

In recent years, however, many of the fumigants and repellents used have become either unobtainable (napthalene) or unsuitable due to the increased knowledge of their effects on humans (Gammatox) or the fact that the insects have built up immunities to the poisons. A new, effective fumigant was therefore urgently required. Coopers (Zimbabwe) and Coopers (South Africa) agreed to provide a fumigation service for the entire museum, free of charge, using Vapona and Deltamethrin, provided they could write up the results of the exercise and obtain some publicity. A good deal of research has been carried out on the use of Vapona as a fumigant in museum collection, its effects on the specimens and on humans. In the light of many favourable reports, it was agreed to go ahead. The results were favourable and an article describing the experiment will appear in *Curator* in due course.



All specimen cabinets are now fumigated regularly with vapon strips on a rotational basis, and the entire building is fumigated twice a year with DDVP (the active ingredient of Vapona) dissolved in carbon dioxide and administered as an aerosol spray. The longterm effectiveness of this system and the chemical itself, remain to be seen.

#### DOCUMENTATION

In the past, documentation of mammal specimens in the National Museum was poorly carried out for a number of reasons. The reasons will be listed here to provide examples from experience of what not to do while developing collections.

During the 1950's and 1960's, the government departments dealing with the control of Tsetse Fly in Zimbabwe (Southern Rhodesia) and Zambia (Northern Rhodesia) culled many thousands of game animals. The National Museum took the opportunity to salvage as many of the skins and skulls of these culled animals as possible. As a result, there was an influx of specimens into the collection so great that there was not enough time to document all the specimens properly. Although field registers were kept, few measurements were taken due to the volume of material the field workers were dealing with. Geographical localities were often lacking and specimens were either not labelled correctly or not labelled at all.

Although this collection of mammals has been used for several research projects, its use has been limited due to the paucity of associated data. Much of the material was never accessioned, and thus there was no way of accounting for loss of specimens, or even of knowing the size and scope of the collection.

In addition, during the past twenty years, there has been a succession of curators of mammals, each with different ideas on work priorities and designs for documentation procedures. At one stage it was policy not to accession specimens at all, but rather to maintain an official listing of collectors prefixes and retain documentation by collector. This has made it extremely difficult to ascertain what is in the collection, how large it is, and most important, what is missing. In 1976, the Director and Curator of Mammals decided on a policy (which should survive each successive curator) for accessioning and documenting all mammal specimens in a standard fashion. The need for establishing a fixed policy for the acquisition and documentation of specimens to provide continuity cannot be stressed strongly enough. In order to avoid wastage of valuable specimens, quality should take precedence over quantity in collecting policy, especially in today's climate of conservation awareness.

Data acquisition, storage, and retrieval in the National Museum, Bulawayo, has already been covered (Wallace, 1976). The system was developed to provide a cross-reference system to simplify data retrieval, bearing in mind the possibility of computerisation in the future. An example of each label and data card has been included below for reference (Figs. 3, 4, 5).

Labels for dry specimens are manufactured from standard resistal paper, and labels for "wet specimens" are made from syntosil paper (Smithers, 1973). Both types of paper are available from Burnett Paper Ltd., Beta House, Rectory Lane, Station Rd., Edgware, Middlesex HA8 7LG, England. Syntosil paper was developed during the second World War to be used for Admiralty maps and charts carried at sea. It is virtually indestructible, and a very good medium for use in labelling "wet specimens." Resistal paper has been found to disintegrate in Isopropanol over time, whereas syntosil has lasted well, over nearly thirty years.

#### GENERAL COMMENTS—FITTING THE MUSEUM INTO SOCIETY

As can be seen from this discussion, the problems experienced in the National Museum, Bulawayo, are problems which every museum faces. However, in many third-world countries, the problems become more acute due to lack of funding, isolation, and often to a lack of properly qualified back-up staff. By publicising our institutions we may eventually be able to attract foreign workers to our collections. Each visitor is able to provide a fresh viewpoint, helpful criticism and new ideas. Conferences, such as this one, are useful in that they are held closer to the problem areas, enabling more third-world institutions to send delegates because transport costs are more acceptable.

In Bulawayo, alleviation of some of our difficulties with funding is found in an enthusiastically supportive public. Time and thought have been spent on improving and maintaining our local image. The Museum organisation is seen partly as a public resource. The Ministry of Education in Zimbabwe has provided an education officer for each museum, who plans school programmes and who has established a reputation as a valuable educator. The public is encouraged to utilise the expertise available in the museum staff to answer queries regarding the natural world, and this service is frequently utilised. Advice is given to scholars working on projects, school children occasionally even utilise the collections. Public relations in the form of tours for specially interested people, or groups, is carried out by many staff members, and at all times the director and curators are accessible.

NATIONAL MUSEUMS OF ZIMBABWE

Date \_\_\_\_\_ Sex O\_\_\_\_\_ CoL No. \_\_\_\_\_

Loc. \_\_\_\_\_

Sp. \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_ No. \_\_\_\_\_

OVERALL \_\_\_\_\_

Length Body \_\_\_\_\_

Length Tail \_\_\_\_\_

Length Hindfoot \_\_\_\_\_

Length Ears \_\_\_\_\_

Weight \_\_\_\_\_

Forearm \_\_\_\_\_

Front

Back

Small-mammal Label

NATIONAL MUSEUMS OF ZIMBABWE

Species \_\_\_\_\_

Date Collected \_\_\_\_\_ Sex \_\_\_\_\_

Collector \_\_\_\_\_ CoL No. \_\_\_\_\_

Locality \_\_\_\_\_

Grid Reference \_\_\_\_\_

Habitat \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_ N.M. No. \_\_\_\_\_

Wet Specimen Label

OSTEOLOGY COLLECTION  
NATIONAL MUSEUM

SPECIES .....

N.M. No. ....

SEX .....AGE .....

DATE .....MASS .....

LOCALITY .....

Belmont Printers, Byo.-98656

Skeleton Box Label

Fig. 3.—Labels



**MAMMALS**

N.M. No. ....

SPECIES ..... Q.V.M. No. ....

SEX ..... U.M. No. ....

DATE ..... ALTITUDE .....

LOCALITY .....

GRID REF or BEARING .....

COLLECTOR ..... COLL. No. ....

MEASUREMENTS: Overall .....mm. Tail .....mm.

Hindfoot .....mm. Ear .....mm.

.....mm. ....mm.

WEIGHT ..... lbs. .... ozs., or ..... gms.

REPRODUCTIVE STATUS: MAMMAE Wet/Dry

Number FOETUS .....

Position FOETUS ..... R. .... L.

HABITAT .....

.....

.....

STOMACH CONTENTS .....

.....

.....

NOTES .....

.....

.....

TESTES: Abdominal/Scrotal

TESTES: Weight .....

POSITION MAMMAE .....

FOETAL MEASUREMENTS { Crown/rump .....mm.

Hindfoot .....mm.

Weight .....

TEETH											

Fig. 5.—Standard Mammal Form.

## CONCLUSION

The problems of maintaining a large collection of mammals in a developing nation are, as can be seen, difficult and varied, but they are not insurmountable. Basically, what is required to deal with the problems is common-sense and a little ingenuity. It is very important to maintain communication with other museums, ensuring a flow of new ideas and realising mutual support, even if that support is only ideological. In addition, it is important for back-up curatorial staff to be provided with a sound understanding of what collections and collection management is all about, in order to ensure that staff has sufficient motivation to carry out their tasks effectively.

The collection of mammals in Bulawayo, Zimbabwe, is large, varied, and provides a vast, untapped resource of material for those studying the south-central African fauna. It is hoped that this article will serve to make it better known, and to attract workers to utilise the collection fully.

## SUMMARY

The collection of Mammals in the National Museum, Bulawayo, Zimbabwe, comprises over 80,000 specimens. However, although it is a significant collection in terms of size and scope, it is underutilised due to its remote situation and the difficulties involved in international loans, the postal system and customs regulations.

Several aspects of the mammal collection housed in the National Museum have been dealt with in previous contributions, namely, the problems associated with the osteological collection, the large mammal hides, the collection of spoor casts and scats, and documentation procedures. This paper discusses the preparation and storage of small mammals and medium-sized mammals; insect control; the problems experienced in the past with documentation due to overloading of staff and lack of continuity in documentation procedures; and finally the way in which the museum supplies a service in exchange for contributions and support from the local population, including industry.

In describing the small mammal collection, it is postulated that preparation of skins using heavy magnesium carbonate rather than cornmeal as a dusting powder, and treating the skins with a borax and creosote oil mixture, contributes to the prevention of insect attack. Careful field methods also protect specimens from contamination. All chiropteran material is stored wet in a 5% solution of formalin buffered with hexamine, and jars are sealed with vaseline. Jars are placed on wooden shelves rather than metal ones to decrease the risk of damage by fire.

## REFERENCES

- GENOWAYS, H. H. and SCHLITTER, D. A. 1981. Collections of Recent mammals of the World, exclusive of Canada and the United States. *Ann. Carnegie Mus.*, **50** : 47-80.
- JONES, E. M. 1985. Mammal collection in the National Museum, Bulawayo, Zimbabwe, and its storage. *Acta zool. Fennica*, **170**; 77-79.
- SMITH, J. L. B. 1947. A neutral solution of formaldehyde for biological purposes. *Trans. R. Soc. S. Afr.*, **3** : 279-282.
- SMITHERS, R. H. N. 1973. *The preparation of museum study skins*. Trustees of the National Museums and Monuments of Zimbabwe, Zimbabwe.
- WALLACE, E. M. 1976. The theory and practice of specimen documentation. *S. Afr. Mus. Ass. Bull.*, **13**, 1 : 26-36.

## DISCUSSION

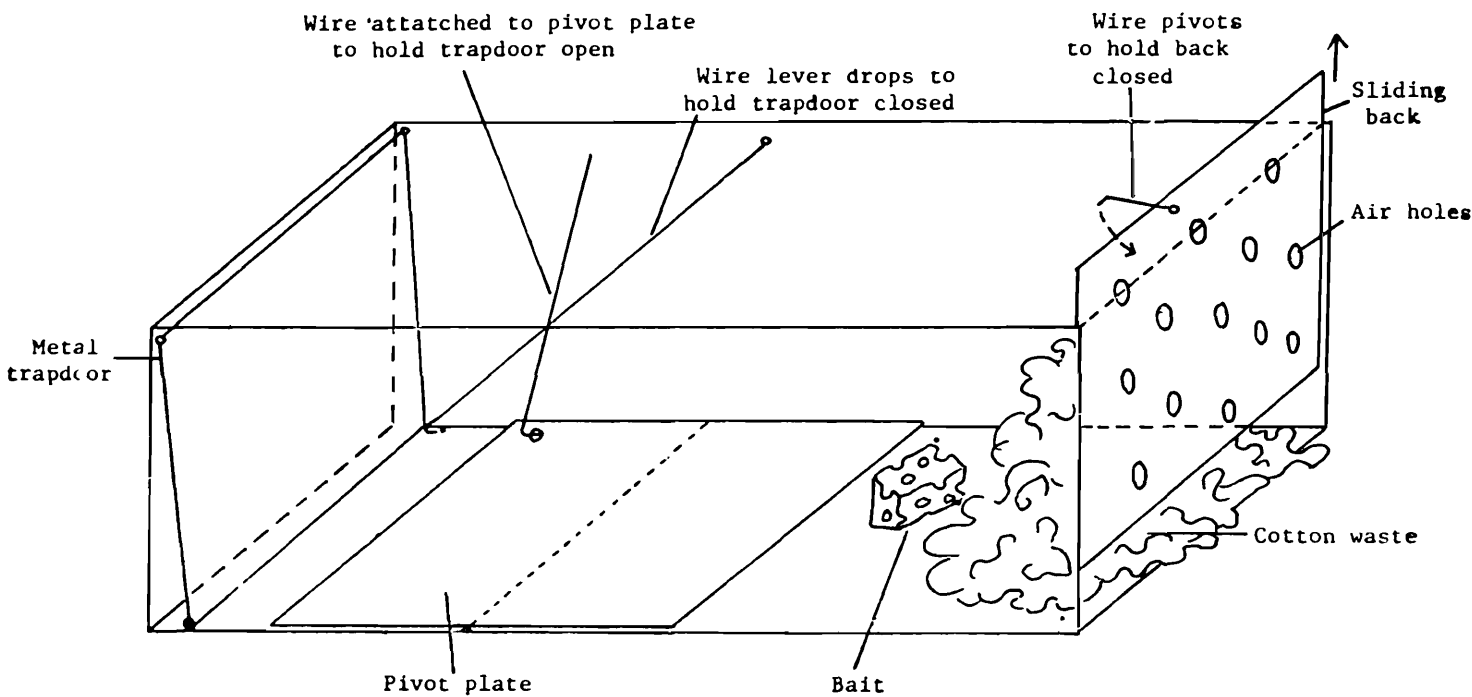
- Q. *All of your chiropteran specimens are now kept in fluid. After a period of time, however, the skull-bones might be altered in shape and size. As skulls are commonly used by systematists, this alteration can affect the results of a systematic analysis. Would it not be better to remove all skulls when the specimens are collected ?*
- A. Yes it would be better. We do, however, make every attempt to neutralise the formalin solution in which the material is stored.
- Q. *Are you recording all details of tanning procedures for each tanned specimen ? This would be important in time in order to evaluate long-term effects of tanning. Please elaborate.*
- A. Yes. We use a modified form based on the one used at Carnegie Museum.
- Q. *What is your suggestion to reduce the possible "Fatburn" during preparation of skins ?*
- A. Careful original preparation of material, e.g., scraping all fat off the skin before stuffing. Also one can wash the skin in soft soap before stuffing.

Q. *What are the advantages of having centralised national reference collections in developing nations ? Are there other collections of mammals in Zimbabwe other than your collection ?*

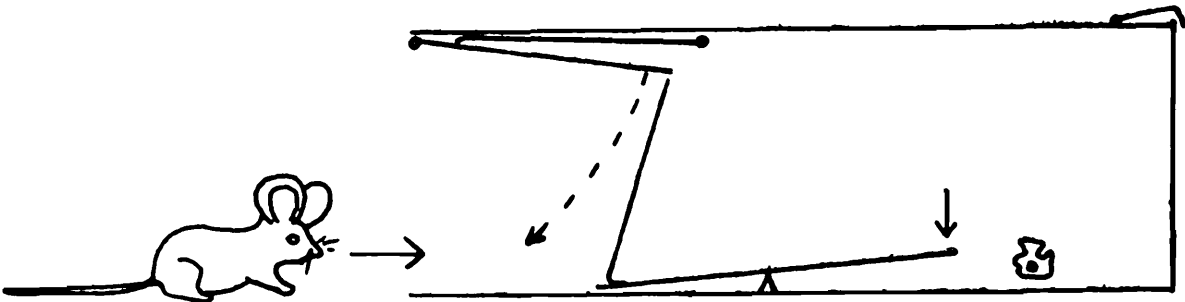
A. Centralised reference collections supply a basis for present and future research of all kinds, both within and outside the country. In addition, the research which is based on collections forms an important educational reservoir for both specialist and layman alike. I am unaware of any other significant or usable collection of mammals in Zimbabwe.



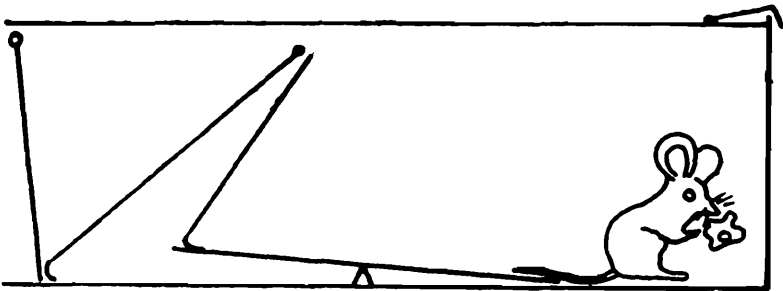
APPENDIX



Appendix : Fig. 1.—Generalised diagram of live trap.

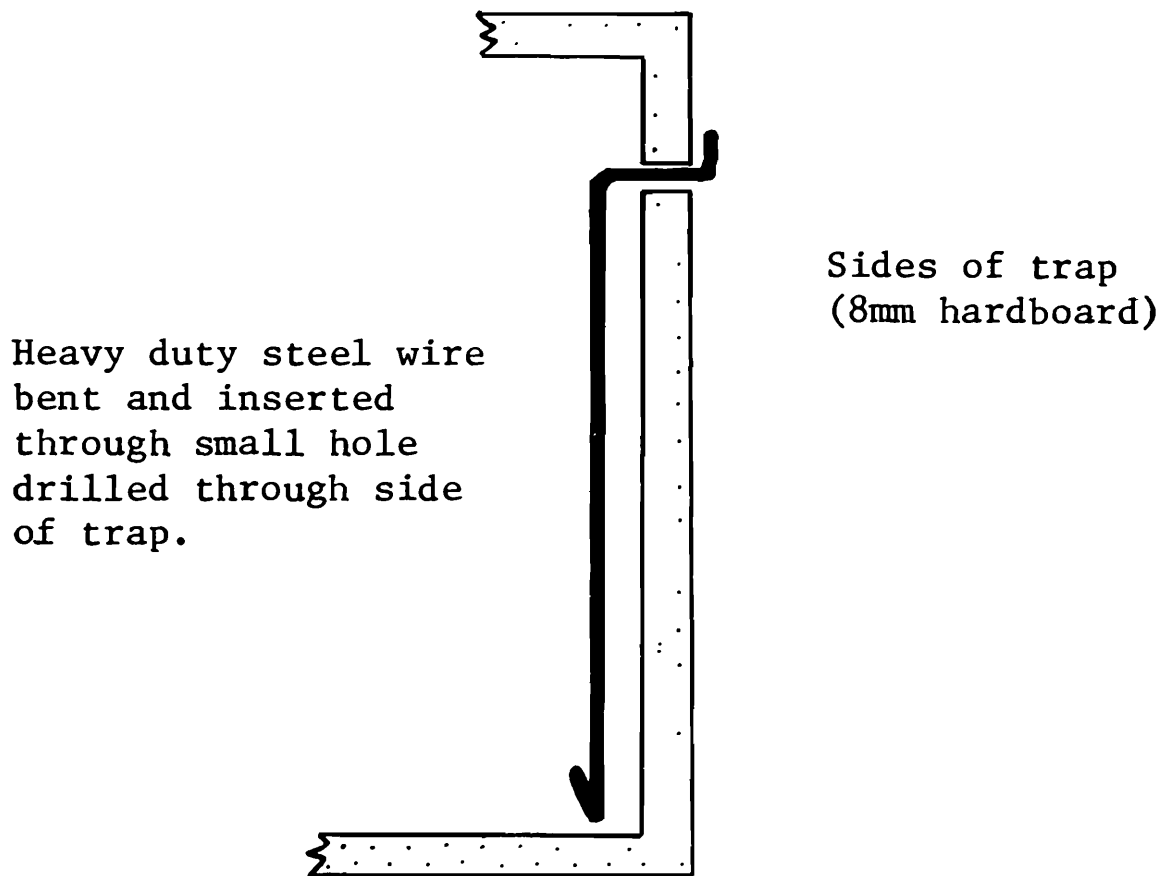


a) Trap set



b) Trap sprung

Appendix : Fig. 2.—Principles on which live trap works.



Appendix : Fig. 3.—Method of insertion of wire levers.

### Design of Live Trap

Length: 290mm

Breadth: 100mm

Depth: 95mm

Materials: 8mm hardboard

sheet iron for trapdoor, back and pivot plate

heavy-duty steel wire

Appendix : Fig. 4.—Specifications of live trap.



## TECHNIQUES USED IN THE THAI NATIONAL REFERENCE COLLECTION OF MAMMALS

SONGSAKDI YENBUTRA

*Thailand Institute of Scientific and Technological Research, Bangkok*

### INTRODUCTION

The Centre for Thai National Reference Collection (CTNRC) of the Applied Scientific Research Corporation of Thailand began its collection in 1966, intending to build up a collection for a national museum and for reference purposes. It is now the collection of the Ecological Research Division, Thailand Institute of Scientific and Technological Research (TISTR), and is the biggest collection of mammals in Thailand with over 9,000 specimens and 7 holotypes. Most of the specimens are prepared as conventional skin specimens. Only bats are preserved as whole bodies in 70 percent alcohol.

### ACQUISITION AND PREPARATION OF MATERIAL

The first phase of developing a mammal collection is the acquisition of the material for the collection. There are only three sources of acquisition of materials in our collection—donations, exchanges, and institutional staff.

*Donations* : The material derived from this source is about 10 percent of all the specimens in the collection and most of these were received from the SEATO LAB collection and Boonsong's collection.

*Exchanges* : Only about two percent of the collection resulted from exchanges, and most of these specimens are from Southeast Asia.

*Institutional staff* This is a major source of material with nearly 90 percent of all the specimens in the collection resulting from collecting by the staff. Most of these specimens are a by-product of ecological research carried out in the Division.

Preparation procedures have been established for preparing specimens in the field by institutional staff, as follows

- 1 *Field catalogue*.—The field catalogue is a written record of all specimens that are collected and preserved in any manner. It is divided into four separate books, one for each geographic region of Thailand—C (central part), N (northern part), S (southern part), and E (eastern part). Each specimen is assigned a field number that begins with the letter C, N, S, or E. This letter is followed by the official code for the abbreviation of the province and then the next running number from the

THAI NATIONAL REFERENCE COLLECTIONS

LINE NO	SPECIMEN NUMBER	SCIENTIFIC NAME	SEX	LOCALITY
1	54-7432	Rattus rattus	♂	Chiang Mai, Doi Pui
2	54-7433	" "	♀	" " "
3				
4				
5				
6				

THAI NATIONAL REFERENCE COLLECTIONS

LINE NO	DATE COLLECTED	COLLECTED BY	ORIGINAL NUMBER	DATE ENTERED	ENTERED BY	REMARKS
1	6 Jul 1983	SY	NCM 1	8 Sep 1983	SY	
2	"	"	NCM 2	"	"	
3						
4						
5						
6						

Fig. 1.—Field notebook for collection for the northern part of Thailand.

appropriate regional field book. After that, the scientific name, locality, collector, and date of collection should be noted in the field catalogue book (Fig. 1).

2. *Measurements, weight and sex.*—Mammal specimens should be measured and weighed prior to preparation. The measurements are listed in the following order : 1) head and body length (HB) from tip of nose to anus, 2) tail length (T) from anus to the tip of tail bone, 3) hind foot length (HF) from heel to most distant claw tip, 4) ear length (E) from base of notch to the uppermost margin of the pinna, and, in bats, 5) tragus height (Tr) from base to tip, 6) forearm length (FA) from the outside of the wrist to the outside of the elbow with the wing folded, and 7) weight (W). The measurements are taken in millimetres and the weight is recorded in grams. The sex should be recorded using the symbols ♂ for male and ♀ for female. Use a question mark (?) if the sex cannot be determined.

3. *Specimen labels.*—For each specimen recorded in the field catalogue, a corresponding data tag should be attached to the specimen (DeBlase and Martin, 1974). Labels or tags that we use for study skins are about 82.5 mm by 82.5 mm (Fig. 2) and all of the data from the field catalogue should be recorded on the study skin tags in permanent ink: field catalogue number, sex, locality, date of collection, name of collector, measurements, weight and scientific name of the specimen. Labels or tags for skulls and field-preserved specimens are only a small piece of resistant paper which have only the collector's name, field catalogue number, and sex of the specimen recorded on them.

*Rattus rattus* ♂  
THAI NATIONAL REFERENCE COLLECTION

*HB 180 T 190 HF 34 E 23 WT 140g*

Field No. *NCM1* Date *6 Jul 1983* Collector *SY*

Locality *Chiengmai, Doi Pui*

Fig. 2.—Field specimen label used by the Thai National Reference Collection.

4. *Specimen preparation and preservation.*—The specimen should be skinned as soon as possible after death (Anderson, 1960; Miller, 1899). If the weather is hot, the viscera should be removed from the specimen immediately, and the abdominal cavity filled with cotton or toilet paper. Therefore, specimens that are trapped alive should be kept alive until the collector is ready to skin them. Killing is done in a polythene bag

with a few drops of chloroform. This also serves to kill ectoparasites which can then be collected in tubes in 70 percent alcohol (one tube per mammalian host).

4.1 *Skinning*.—Place the specimen on its back, make a small incision in the skin of the abdominal region, and remove the skin, leaving the car-pals, tarsals, and phalanges in position in the skin. Trim the flesh from the leg-bones and remove any remaining flesh, fat, or glandular tissue from the skin. Check the fur for dirt or blood. If the skin is dirty with blood or grease, remove this by washing the skin in soapy water. After this step, the skin of the specimen can be kept in 70 percent alcohol as long as necessary until the collector has time to mount it. This technique is important when there are a lot of specimens to work with or when the specimen won't dry well in the field, such as in the rainy season. The specimen can be taken back in 70 percent alcohol and mounted in the institute.

4.2. *Mounting*.—Rub powdered borax over the entire skin, fill the skin with cotton wool, close the incision; for medium-sized mammals, the pawpad should be injected with 10 percent formalin. Tie the label above the ankle of the right hind foot, and place the specimen belly side down on a piece of cardboard for drying but not directly in the sunlight. Aerosol insecticide (Dichlorvos 1%+Plifenate 2%) can be sprayed to prevent insects such as flies and ants. Flies will lay eggs on the fur and ants will eat some part of the skin such as ears, etc.

4.3. *Skull preparation*.—Remove the skull from the carcass by disjointing carefully at the neck. Cut off only the large muscle and remove nothing but eyes, tongue, and brain by injecting some water through the foramen magnum with a syringe. The water will push the brain out from the braincase. Tie the skull label and hang up to dry. If there is no time to dry the skulls, they may be preserved in 70 percent alcohol. The cleaning of the skulls is usually done in the institute using dermestid beetles. The skulls that are preserved in alcohol should be washed and dried first before using the beetles to clean them.

4.4. *Fluid preservation*.—In certain mammals, such as bats, the form of the ears, nose, and wing membranes are important for identification. Therefore, a taxonomic collection of bats should always include some wet specimens in addition to dry skins and skulls. The specimens should have an incision in the wall of the abdomen and are preserved in 70 percent ethyl alcohol.

#### PROCESSING, STORAGE AND MAINTENANCE OF MATERIAL

1 *Cataloguing*.—Cataloguing procedures include a sequence of identifying, numbering, and recording events for each specimen of an acquisition (Williams *et al.*, 1977). Identification of individual specimens

is the first phase of cataloguing for the collection, and all identifications are based on the most recent classifications occurring in the literature. Usually our identification process will start after the skull of the specimen has been cleaned. After the specimen has been identified, the catalogue number will be assigned to the specimen.

The catalogue number or specimen number for the mammal specimens in our collection start with the code number 54-, and follow with the number in sequence from one. The specimen number, original number or field number, date of collection, collector, locality, scientific name, name of determinator and date of entry should be recorded on the catalogue specimen label (Fig. 3) for each specimen. After that, everything will be recorded again in the catalogue book in the sequence of the running number (Fig. 4). Over the last three years, we tried to make a card catalogue entry for each specimen (one specimen corresponding with one card in the file). Data recorded on these cards are scientific name, catalogue number, locality, collecting date, biological comments, mode of preservation, collector, and all the measurements (skins and skulls) (Fig. 5).

2. *Storage*.—The specimen with the catalogue label should be matched with the skull which has the same catalogue number written on it. Make sure that the specimen is completely dry and that there are no signs of insect infestation in the skin and skull. If there are some signs of infestation, put the skin and skull in a polythene bag with few drops of chloroform. Glass vials are used for storing the skulls of small mammals and are kept together with the skins on paper trays. Put the trays in the drawers of an air-tight cabinet. Two or three naphthalene balls should be put in one drawer. Plastic vials cannot be used as they can be melted by naphthalene.

Specimens preserved in alcohol should be stored in wide-mouth jars with rubber washers and glass lids held firmly in place by wire bails. These should be stored on metal shelving in a dark room because alcoholic specimens are sensitive to sunlight.

THAI NATIONAL REFERENCE COLLECTIONS

Name *Rattus rattus thai* ♂

Det. *SY* Date *8 Sep 1983*

Specimen No. *54-7432* Original No. *NCM 1*

Date *6 Jul 1983* Collector *SY*

Locality *Chiangmai, Doi Pui*

Fig. 3.—Catalogue specimen label used by the Thai National Reference Collection.



No. Sex	Date	Collector	Name	Locality and Habitat	Measurement and Remark
NCM 1 ♂	6 Jul 1983	SY	Rattus rattus	Chieng Mai, Doi Pui	180:190.34:23:140g.
NCM 2 ♀	"	"	"	" "	
NCM 30 ♂	9 Jul 1983	"	"	Chieng Mai, Doi Pui	
NLP 31 ♀	20 July 1983	"	Mus colori	Lampang, Chae Hom	

Fig. 4.—Collection catalogue used by the Thai National Reference Collection.

*Rattus rattus*

เลขทะเบียนที่  
Catalog No.  
54-7432

สถานที่  
Locality *Chieng Mai, Doi Pui*

วันที่เก็บ  
Collecting date *6 Jul 1983*

เพศ  
Sex ♂  
อายุ  
Age *adult*

ชีววิทยา  
Biology

Skull - Skelleton - Stuff specimen - Skin - Alcohol

ผู้จับ  
Collector *Songsakdi Yenbutra*

สิ่งตีพิมพ์  
Publication

เลขที่  
Field No.  
*NCM 1*

Body measurment		14:	Skull measurment		14:	28:
1:		15:	1:		15:	29:
2:	<i>180</i>	16:	2:	<i>140g</i>	16:	30:
3:	<i>190</i>	17:	3:		17:	
4:	<i>34</i>	18:	4:		18:	
5:	<i>23</i>	19:	5:		19:	
6:		20:	6:		20:	
7:		21:	7:		21:	
8:		22:	8:		22:	
9:		23:	9:		23:	
10:		24:	10:		24:	
11:		25:	11:		25:	
12:		26:	12:		26:	
13:		27:	13:		27:	

Fig.—5 Catalogue card used by the Thai National Reference Collection.

3. *Maintenance*.—Our collection of mammals is small and the maintenance cost is very low. Usually we try to avoid most maintenance problems by preventive measures. The specimens must be prepared as carefully as possible before being placed in the collection. The collection will be checked for pests and dust every month. The only pests that cause damage to our collection are beetles. If they are found, the specimens will be put into plastic bags with a few drops of chloroform. The entire collection is dusted once a year. For fluid-preserved specimens, a regular inspection schedule should be established once a month to ensure that the specimens are covered by the preservative (70 percent alcohol).

#### THE USES OF COLLECTION

There are only a few collections of mammals in Thailand and CTNRC is the biggest one. As such, it serves all of the scientists and students in Thailand who want to work with mammal specimens. Usually the CTNRC doesn't permit the loan of specimens out of the collection, but any person can come to use the collection during working hours. Only a person who has a letter of recommendation from a university, institute, or museum can borrow specimens from the collection.

#### NATIONAL LEGISLATION

The most important law in Thailand concerning collecting of material is the Wild Animals Preservation and Protection Act (Lekagul and McNeely, 1977). This Act became law on January 1, 1961. It is designed to control hunting; establish hunting seasons; prohibit the hunting, capture, or trade of certain rare species; limit the species and numbers which can be kept in captivity; enable reserves to be established for the purpose of conserving wildlife; and establish a Wildlife Advisory Committee to determine closed seasons, establish reserves, place species in the various protected categories, and advise on rules and conditions concerning permission to hunt and trade in wild animals.

Species affected by the Act are placed in two categories—Reserved and Protected. Reserved species are considered extremely rare and endangered and cannot be hunted, collected, or kept in captivity except under very special conditions. Some are already extinct or nearly so (Table 1).

The Protected species are not in immediate danger of becoming extinct, but require regulation to prevent their populations from becoming dangerously depleted. Protected species are placed on two schedules. Schedule 1 animals (Table 2) are those which are not usually hunted for

meat and their hunting, capture, or keeping in captivity are allowed only under license. Schedule 2 animals are the game species which have historically been hunted for meat or sport (Table 3). Hunting of these species is allowed under license by appointed officials.

The act is enforced by the Wildlife Conservation Division of the Forest Department, police officials, forest police officials, provincial governors, and chief district officers. Those convicted of breaking the hunting law are subject to one year imprisonment and a fine not exceeding 10,000 baht (\$500 US).

### SUMMARY

There are only a few collections of mammals in Thailand. The Thai National Reference Collection now is the collection of Ecological Research Division, Thailand Institute of Scientific and Technological Research (TISTR), and is the largest collection of mammals in Thailand with the 9000 specimens and 7 holotypes. The techniques that are used to manage the collection usually follow the techniques of the national natural history museums in the United States and European countries, but our own techniques for acquisition, preparation processing, storage maintenance, the uses of collection and national legislation are described in detail.

### REFERENCES

- ANDERSON, R. M. 1960. Methods of collecting and preserving vertebrate animals. (3rd ed. rev.). *Natn. Mus. Can. Bull. No. 69, Biol. Ser. 18* : 1-164.
- DE BLASE, A. F. and MARTIN, R. E. 1974. *A manual of mammalogy* : 1-323. Wm. C. Brown Co. Publishers, Dubuque, Iowa.
- LEKAGUL, B. and Mc NEELY, J. A. 1977. *Mammals of Thailand* : 1-747. Kurusapha Press, Bangkok.
- MILLER, G. S., Jr. 1899. Directions for preparing study specimens of small mammals. *Bull. U.S. Natn. Mus., Part N, 39* : 3-10.
- WILLIAMS, S. L., LAUBACH, R. and GENOWAYS, H. H. 1977. A guide to the management of Recent mammal collections. *Spec. Publs., Carnegie Mus. Nat. Hist., 4* : 1-105.

Table 1

**Reserved species**

1. *Rhinoceros sondaicus* 2. *Dicerorhinus sumatrensis* 3. *Cervus eldi* 4. *Cervus schomburgki* 5. *Cervus porcinus* 6. *Bubalus bubalis* 7. *Bos sauveli* 8. *Capricornis sumatraensis* 9. *Naemorhedus goral*

Table 2

**Schedule 1 : Protected species**

- 1 *Cynocephalus variegatus* 2. Primates (all) 3. *Manis* (both) 4. *Hylopetes* (all) 5. *Petaurista* (all) 6. *Ratufa* (both) 7. *Atherurus macrourus* 8. *Hystrix brachyura* 9. *Mustela* (all) 10. *Martes flavigula* 11. *Arctonyx collaris* 12. *Melogale personata* 13. Lutrinae (all) 14. *Viverricula malaccensis* 15. *Viverra* (both) 16. *Prionodon* (both) 17. *Arctictis binturong* 18. *Hemigalus derbyanus* 19. *Cynogale benetti* 20. Felinae (all) 21. *Elephas maximus* 22. *Tapirus indicus*

Table 3

**Schedule 2 : Protected species**

- 1 *Selenarctos thibetanus* 2. *Helarctos malayanus* 3. *Panthera tigris* 4. *Panthera pardus* 5. *Tragul* (both) 6. *Muntiacus muntjak* 7. *Cervus unicolor* 8. *Bos gaurus* 9. *Bos javanicus*

**DISCUSSION**

*Q. What is the temperature in the oven where you dry your specimens?*

*A. Between 50° and 60° C.*

## **CAPTURE OF MAMMALS BY TRAPS FOR STUDY PURPOSE**

**R. K. GHOSE AND V. C. AGRAWAL**

*Zoological Survey of India, Calcutta*

### **INTRODUCTION**

Various types of firearms are now in use for sports, game-hunting, and collecting of animals for research and museum exhibit purposes. But the collecting of animals with a firearm is a matter of chance. First, because majority of the mammal species are nocturnal and second the tropical forests of our country are unpenetrable to vision due to thick undergrowth. Therefore, the sighting of an animal is very difficult. As such we depend mainly on mechanical methods like trapping, netting, etc., some of which though not very effective yet reduce the chances of damage to specimens, particularly their skulls.

The traps used in India come broadly under two categories, namely, dead fall traps and live traps. In addition to these, some traps and snares which are made indigenously, are being used by aborigines for sports, game-hunting, etc. However, minor modifications in one or the other type of the commercial or aboriginal traps are not uncommon. Various designs of traps have been suggested by Bourke (1925), Venkatasubban (1948), Kirkpatrick (1955), Abraham (1958), Naider (1962), Batra (1969), Fitzwater (1969), Barbehenn (1969), Agrawal (1981), etc. However, some traps and snares widely used in India are dealt with in this paper. The success in a trapping operation is achieved by the use of right kind of trap, its mechanical condition, proper setting, suitable bait, etc. Hence, these factors have also been briefly touched.

### **DESCRIPTION OF TRAPS**

#### **Dead Fall Traps**

##### *Tanjore bamboo trap*

This consists of three pieces of bamboo tied in the form of a triangle. One of the three bamboo-pieces is longer than the other two and works as a stake of the trap. One end of a bow string is tied with the upper end of the stake. The opposite end of the bow is then fixed with a long stick, which works as a lever. The side of the lever pole is then tied at the junction of the horizontal 'V' of the triangle. The lever pole works

by a loop to which the bait is set. The bow of the trap is kept at high tension and the trap is fixed to the puddle. The bait, generally of paddy, is placed beneath the horizontally placed arm of the triangle, close to the ground. On either side of the straw, puffed rice is kept for enticing

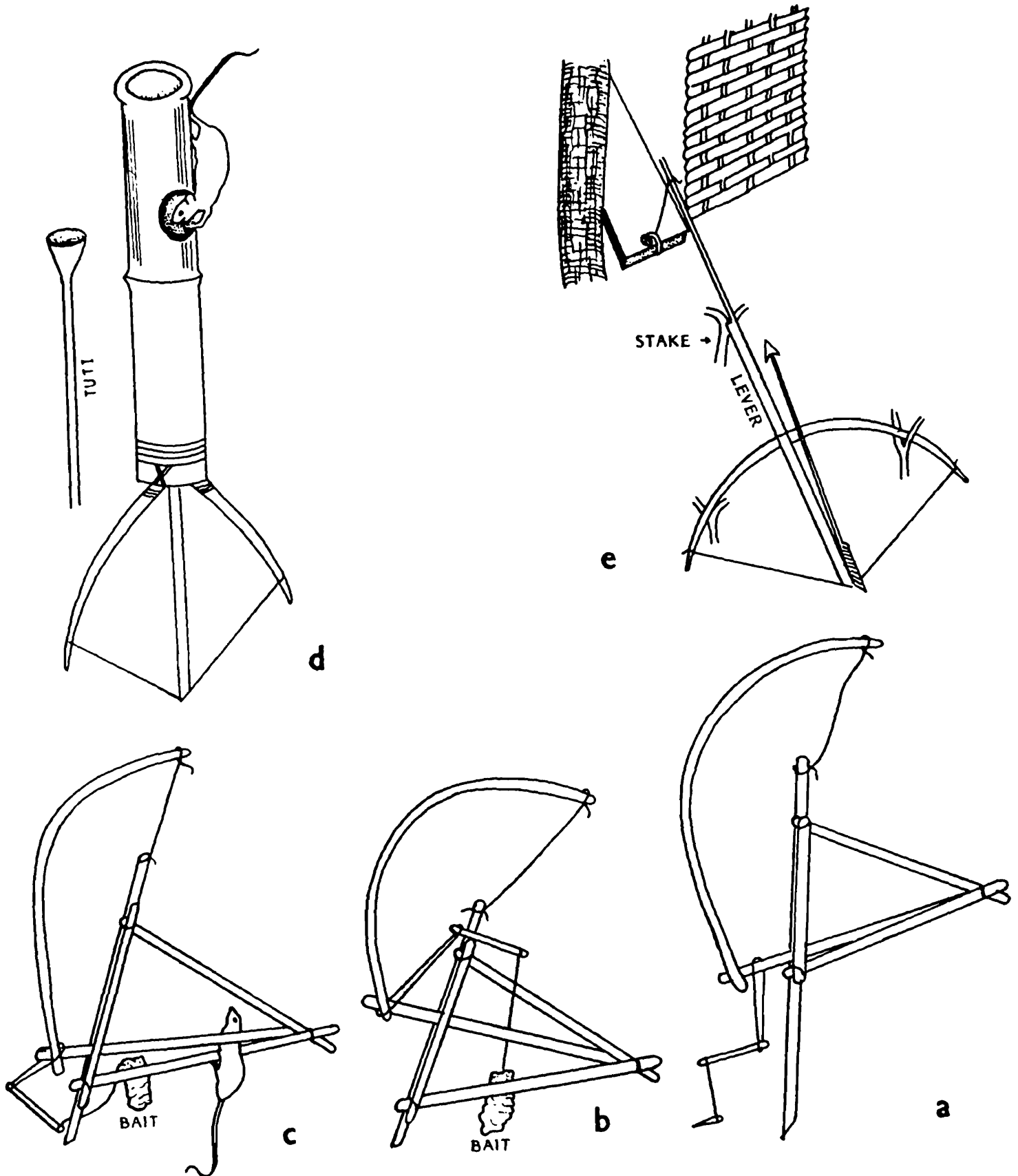


Fig. 1.—Sketch of some dead fall traps. *a*, Tanjore bamboo trap ; *b*, Tanjore bamboo trap in set position ; *c*, Tanjore bamboo trap with catch ; *d*, Urang rat trap ; *e*, Panther trap.

the animal. The animal while eating, disturbs the set position of the trap. The bow straightens and the animal is caught at the neck. This trap is generally used for catching small animals like rats, hares, etc. (Figs. 1a, b, c).

#### *Urang rat trap*

It consists of a hollow bamboo in which an entrance hole is made at one end. A small bow (called 'Tuti') holding a blunt headed arrow is fixed to the open end of the bamboo and the bow-string is pulled tight by a bamboo splinter, wedged against a node inside the bamboo. The bait is fixed to one end of the splinter, the other end of which is set on the bow-string. An animal which touches the splinter in quest of food dislodges it. The arrow, being released automatically, kills the animal (Fig. 1 d).

#### *Bow and arrow trap*

*Panther trap* : In this trap a bow is tied to two small 'Y' stakes, facing the narrow opening of a fence through which the animal enters. Another 'Y' stake is planted in front of the bow. A piece of bamboo, rounded at one end and notched on the other, is taken. While the notch is fixed against the anterior 'Y' stake, the rounded end holds the bow-string backwards. The anterior end of the bamboo is then tied with a small wooden plank, placed in the open gateway. An arrow is set facing the gate. The whole trap is set with great care. The bow is so set that the arrow flies diagonally upwards. A leopard trying to enter through the opening of the fence, steps on the wooden plank and immediately releases the arrow, which strikes the animal in the chest or head, and kills it. This is a trap which is usually used by Urangs in southern Bihar and northern Orissa to save their cattle from panther-attack. It can also be used in the forest by setting a "kill" inside the fence (Fig. 1e).

*Tiger trap* : Three large bows, capable of propelling arrows (120 to 150 cm in length) carrying barbed head of iron (22 to 25 cm long) are taken. These bows are set in a triangle around a kill. Then each bow is set for firing with a trip-string. The bows are so aligned that the arrow, which travels with considerable velocity on release, fly about 50 cm above the level of the ground. At a reasonable distance around this setting, a life saving thread, called the 'Dharamsuta', is set at chest-height above the ground, to warn human-beings about the setting of this trap. A carnivore on its way to the 'kill' touches the trip-strings, which releases the arrow, either causing a mortal wound on the animal or killing it instantly. This trap is, however, very effective for gun-shy animals, which do not usually return to the kill after taking the first meal from it during prebaiting (Figs. 2 a, b).



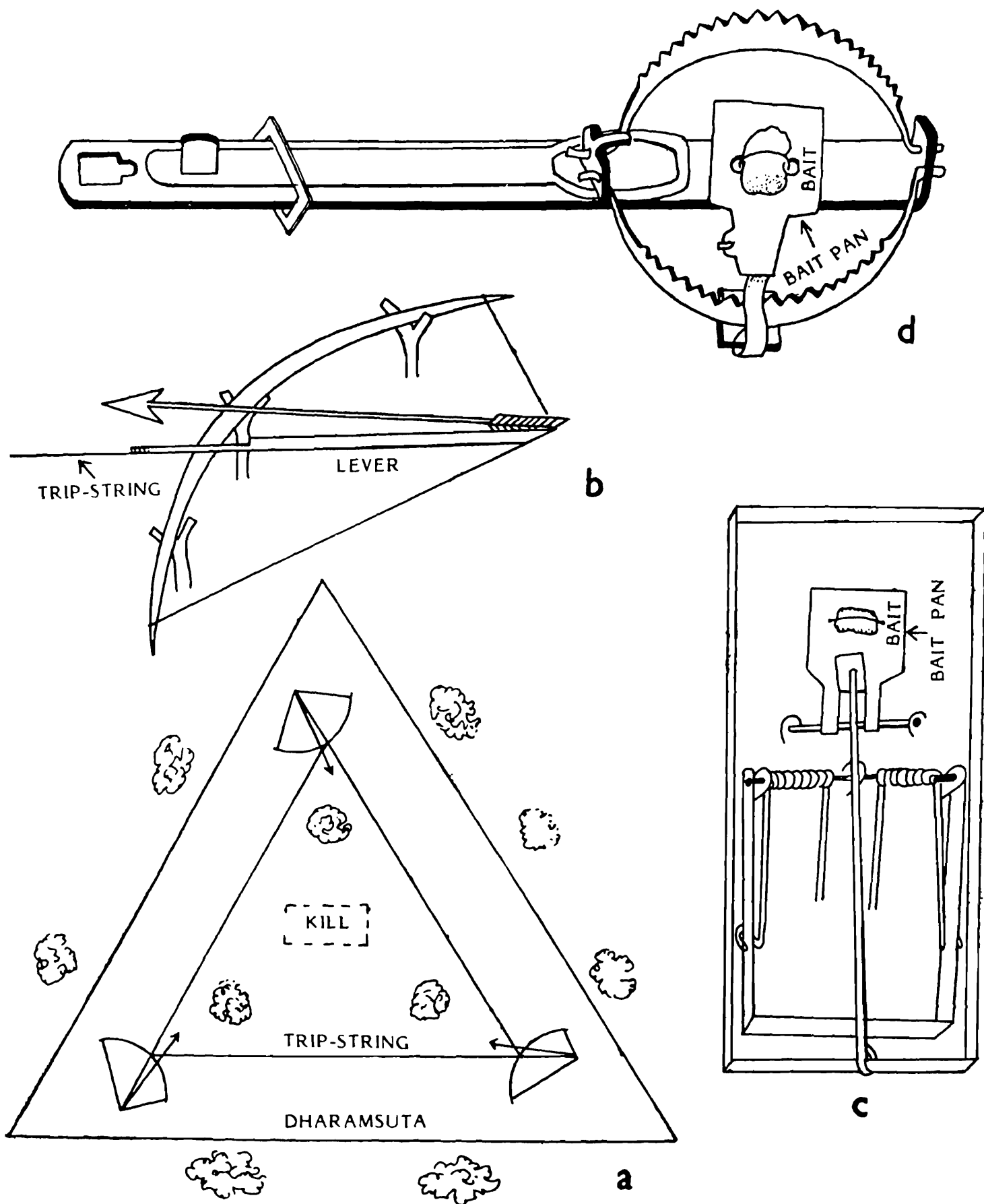


Fig. 2.—Sketch of some dead fall traps. *a*, Tiger trap ; *b*, enlarged view of the bow and arrow in Tiger trap ; *c*, Breakneck trap ; *d*, Breakback trap.

*Breakneck or breakback trap*

These are the most commonly used traps having spring operated devices, used mostly in catching animals of the size of rats, shrews, etc. In this type, the trapping arrangement is so sensitive that it kills the animal instantly, as soon as the latter touches the bait-pan. However, in the breakneck type of trap, the occipital region of the animal's skull is very often damaged, making it unsuitable for scientific study. These traps are suitable for field rodents (Figs. 2 *c, d*).

**Live-Traps***Multiple catch trap*

*Wonder trap* : This trap has a counter-balanced entrance. In this type, when an animal enters the trap, its weight makes it fall into the cage below. The counter balance on the trap-door brings it back into place. This trap takes more than one animal at a setting and is suitable for commensal forms like house-rats, shrews, etc. (Fig. 3 *b*).

*Single catch traps*

*Remote-triggered-door trap* : Examples of this type of traps are : Wooden trap, Jananese wire trap, Sherman trap, Weasel trap, etc. These traps work by upsetting a delicate balance, when the bait-stick is disturbed by touching. Although such traps hardly catch more than one animal at a setting, these are more effective than the multiple catch trap for field-rodents (Fig. 3).

*Pit-traps* This is a steep-dug trench or hole into which an animal falls. Such type of traps with local modifications in devices, are still used in India largely for big animals like elephants, but also for smaller ones. The catching of elephants in 'pit-traps' is commonly known as "Khedda Operation" and is practiced in some parts of India like Karnataka, Orissa, Assam and Bihar. In this method the elephant is driven and made to fall in a pit loosely covered with twigs and branches of trees. It is then caught, starved to make it weak, and then tamed. In pig-trap, a field is fenced and a few gaps are left in the fencing to allow the pigs to visit the field regularly. These gaps are then alternately closed for a few days, keeping the others open. In the temporarily closed gaps, a 'Y' shaped ditch about 120 cm deep, is dug in each gap. The upper 'V' section of the ditch is about 60 cm across. The ditch is loosely covered with branches of trees, twigs and earth. These gaps are now opened. The pig walking over this false setting, falls in the ditch with

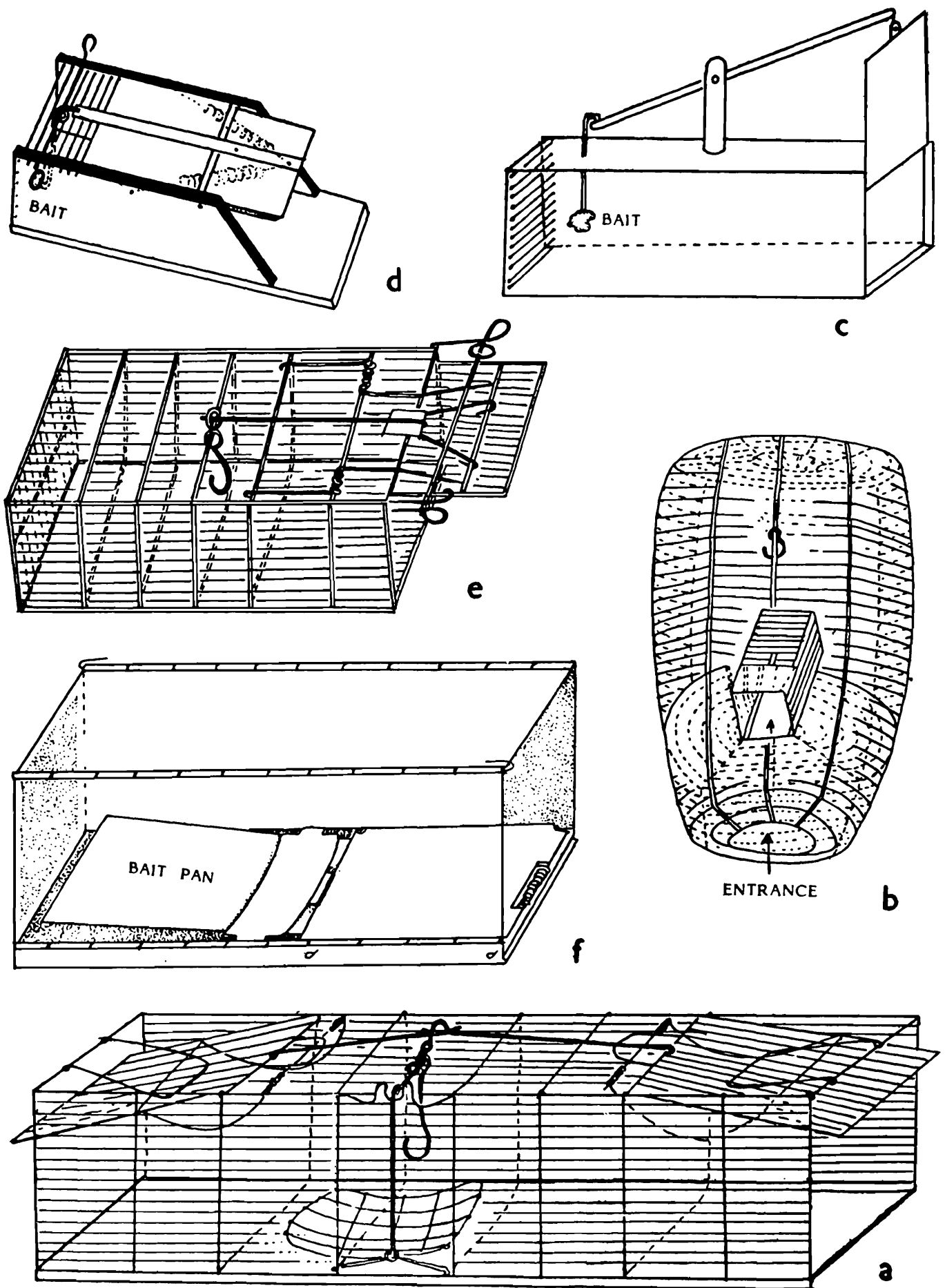


Fig. 3. —Sketch of some live-traps. *a*, Weasel trap ; *b*, Wonder trap ; *c*, *d*, Wooden traps ; *e*, Japanese wire trap ; *f* Sherman trap.

its body wedged into the upper 'V' and the legs dangling in the narrow section, without touching the bottom (Fig. 4).

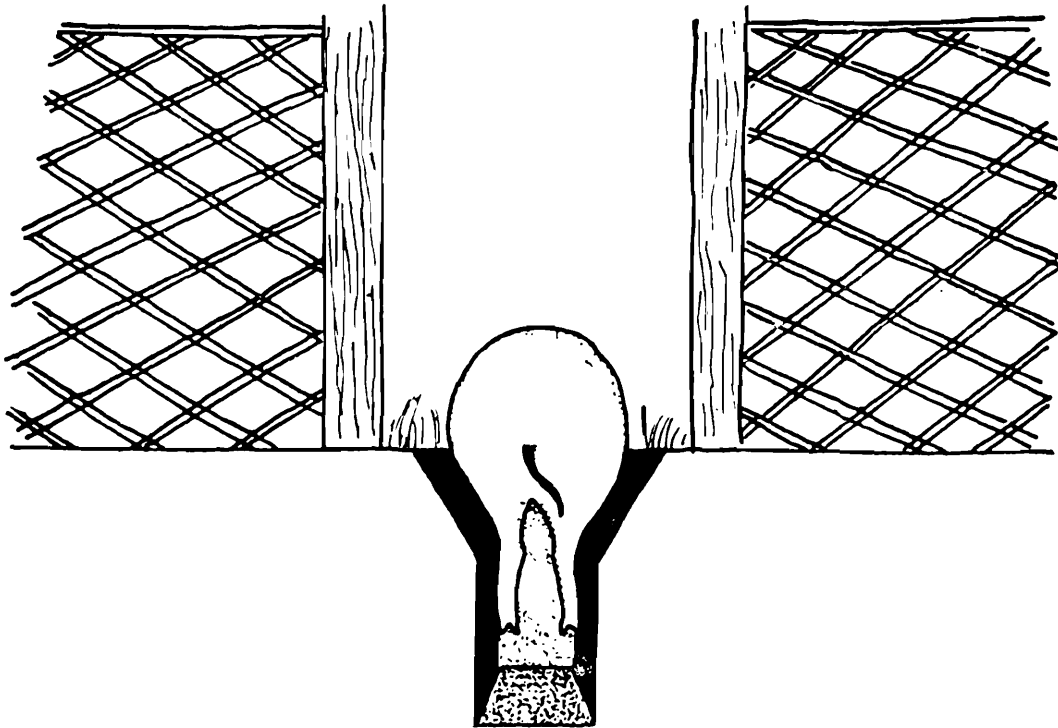


Fig. 4.—Sketch of a pit-trap with catch of a pig, shown from tail end.

*Snare traps* : This trap is used mainly for catching wild cat, fox, hare, etc., and sometimes is operated over the burrow openings of rodents. Generally, for catching foxes and wild cats, a shallow hollow, 12 to 15 cm deep, is dug and a stake is fixed in the centre. A noose made up of string, of about 60 cm circumference, is set around it, and its other end is tied to a bamboo or a splint over head at about 3-3.5 m above the ground. A second string attached to the stake is tied with the string of the noose in such a manner that the bamboo or the sapling bends over it in the form of a spring. The bait (meat or intestine of animal is tied to the stake. The jungle cat, fox or any other predator, which comes to dislodge the bait, loosens the stake and the bamboo flies back to its normal position. Consequently, the animal is noosed around the neck or chest. For catching hares, no pit is made but the bait, such as grain, rice, etc., is sprinkled in the centre of the noose (Fig. 5).

*Net-traps* : Many of us are acquainted with the nylon "mist net" which is used for catching bats, either near their roosts or in their feeding area. While "mist net" is a recent introduction in India, net-traps of various sizes and shapes have been used throughout the country since long. Many of these are set on the ground among the bushes or on the trees, for catching hares and monkeys respectively.

The practice of catching langurs with nets is prevalent in many parts of the central and eastern India. For catching langurs alive, the

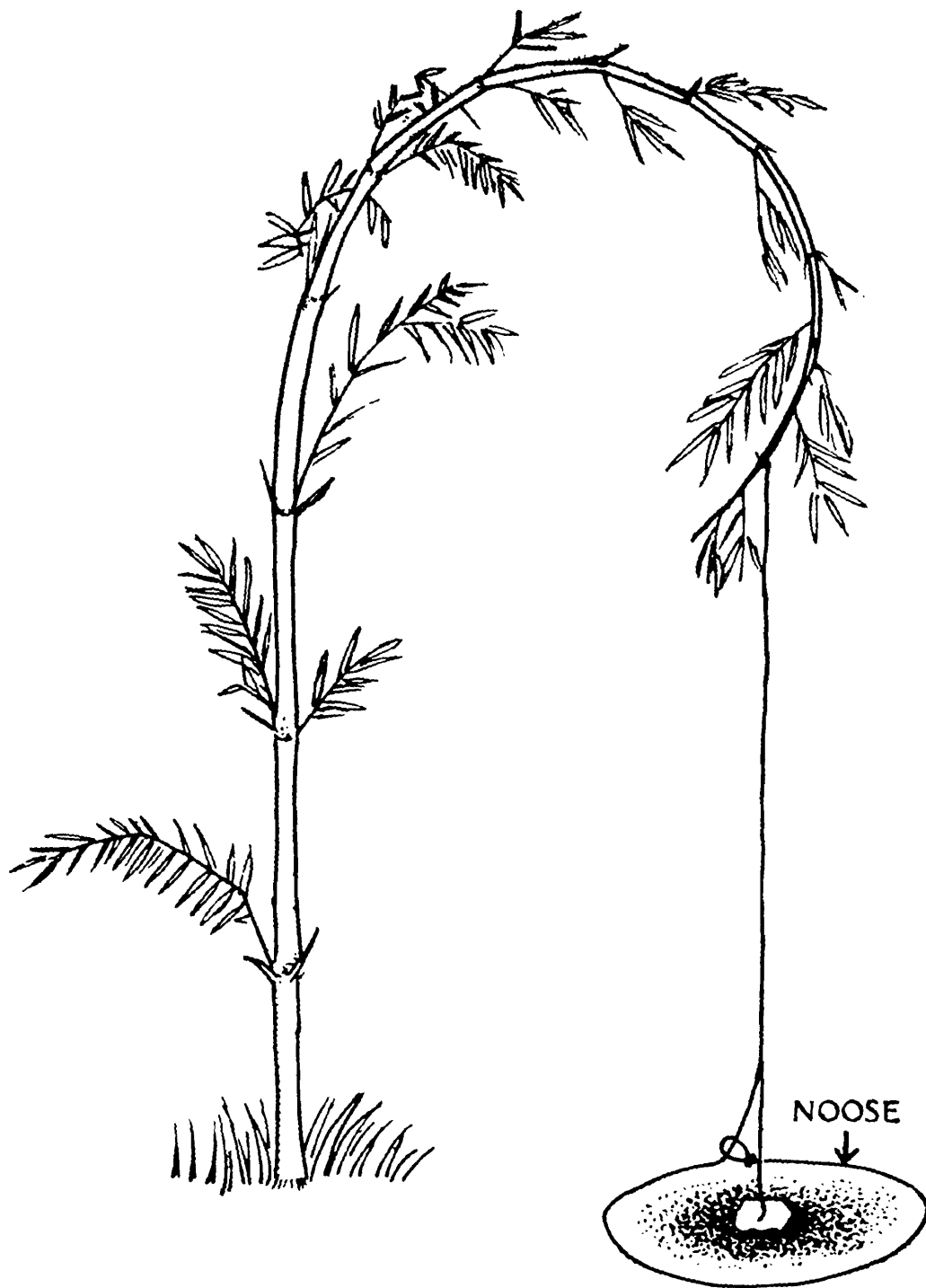


Fig. 5.—Sketch of a snare trap in set position.

regular movement route of these animals are watched. Afterwards, a selected branch of a tree is carefully cut on the underside so that the proximal portion of it loosely hangs by a very small connection on the upper side. Then bag-like nets woven with creepers are hung beneath the cut branches. Monkeys approaching these branches are disturbed by noise created by the people awaiting at a distance. Some of the monkeys, while making quick movements, break the cut branches by their own weight, slip down and are trapped in the bag-nets.

*Hare trap* In this trap a long low barrier is erected in the shape of a large 'V' using the cut branches of trees. At the apex of the 'V' and

at intervals between the arms, some gaps are left. These gaps are covered with loose nets, the ends of which are pegged to the ground. When the animals like hares are disturbed in the forest by the trappers, they run in panic through the arms of the 'V' and are immediately caught in the net-traps.

*Glue-trap* : The animals get entangled in some sticky substances, like the bird-lime, and are caught alive. Although this method is chiefly used for catching birds, it is equally effective for small and large-sized mammals. This method is prevalent in Madhya Pradesh.

In practice, the tracks of the animals are covered with large leaves (preferably dried ones), smeared thoroughly with bird-lime made from Pipul tree-latex and mustard oil. The animal, which may even be of the size of a tiger, walking through that path, puts its feet on the leaves, which adhere to it. As the animal tries to shake off the leaves, it collects more of them on the feet and legs. It then tries to lick the leaves off, but still more adhere to its mouth, head, and ultimately the eyes. The animal starts roaring out of fear and rolls on the leaves. The trappers, waiting nearby, catch the animal with nets or kill it with arrows.

#### FACTORS RELATED TO TRAPPING

##### *Setting of traps*

Animals are trapped either for some specific study or to know the faunal composition of an area. Different strategies are adopted for the same.

To know the faunal composition of an area, especially of small mammals, a suitable area in each of the different habitat-types such as cultivated field, waste land, pastures, orchards, hillocks, river or nullah-sides, caves, etc., is selected. Traps are set at an interval of 7-10 m throughout the area. For studying the population of rodents, these are set in a rectangular grid-pattern, as it ensures easy calculation of the size of home-range, etc. When the place is irregular, no geometrical system is followed and the traps are scattered evenly over the area.

The task of setting the traps is a bit difficult, if a particular species of animal is to be collected. It requires a good deal of experience and knowledge of the habits and habitat of the animal to be caught. At the onset, the approximate place of visit of the animal or its track is carefully watched for a number of days. If the animal is highly secretive or nocturnal, presence of their pug-marks, scats, etc., help in finding the areas of its visit. Burrow openings, heaps of fresh mud, shallow sitting

places devoid of grass, tracks in the grass-field, etc., are indicative of the presence of burrowing rodents, moles, lagomorphs, etc.

Traps are set along the track of the animal. For trapping fossorial animals, it is set a little away from the burrow-openings. Breakneck traps are generally placed perpendicular to the track of the animal and live-traps are placed parallel to the track but slightly away from it. For trapping arboreal animals, the traps are tied on the trunk of the tree with a piece of wire or nailed so that it may not fall down.

For trapping field rodents, insectivores, and lagomorphs, Japanese wire traps, wooden traps, Sherman traps, breakneck traps, snares, etc., are more effective. These are sometimes camouflaged with a layer of mud or smeared with manure. Care is also taken that the trap is firmly set on the ground to prevent any wriggling, when the animal is about to enter it. The base of the breakneck trap is kept in level with the ground. It is tied to a nearby bush to prevent its loss. For indoor-animals like the house-rat or mice, wonder traps serve the best purpose.

Second important factor is the size. The traps should not be either too big or too small in size as compared to the size of the animal to be caught. A Sherman trap is too small for a large-sized bandicoot-rat or a hare. Similarly, a Japanese wire trap is too large for a mouse. Even if the latter is caught, it may escape through the wire-mesh.

#### *Smell in traps*

There is a popular belief in India that once a rat is caught in a trap, it should be washed before resetting. Animals, no doubt, have the ability to perceive the odour of its own kind, but the odour of the animal or its faeces and urine tends to attract other animals of its kind. Hence, the trap in which a particular species has been caught should not be washed before reuse. However, if an animal like a shrew, which has an obnoxious odour, is caught, it is better to wash the trap before it is set for catching rodents.

#### *Number of traps and duration*

Better results in trapping are always achieved by setting as many traps as possible. The actual number depends on the size of the area, minimum home-range of the species, number of tracks, etc. Traps are generally set at a place for a reasonable time, say 3-4 days, after which these are shifted to a new place.

### *Bait*

Bait is considered to be an important factor in trapping success. The baits given should be fresh. The use of some aromatic substance like peanut-butter or mustard oil gives better results. Use of some exotic food as bait attracts the animal. Besides giving the bulk of the bait inside the trap, a little is sprinkled all around it. Some of the commonly used baits are nut, cheese, bread, peanut butter, fried pakora, roasted dry fish, intestine of dead animals, meat, pressed rice mixed with peanut-butter, etc.

### *Mechanical condition and checking*

One of the most important factors in trapping is the mechanical condition of the trap. Before setting a trap, its working condition and sensitiveness should be checked. The spring should not be too tight or too loose.

After setting the trap, it is necessary to check it at regular intervals as precaution against heat or cold, predation or mishandling. However, for diurnal animals, traps are set in the early morning and checked at least in the morning, forenoon, and evening. For nocturnal animals, these are set in the afternoon and are checked in the evening, midnight and early morning.

## SUMMARY

The collecting of mammal specimens with firearms is easy when the animal is visible and within the shooting range. However, the sighting of an animal in dense tropical forests is a matter of chance and luck, specially when the majority of mammalian species are nocturnal. For collecting purpose, therefore, we depend on mechanical methods like trapping, netting, etc., which also reduce the chances of damage to specimens, particularly their skull. In this paper, an account of various traps used in India is given. Also, factors related to the successful capture of animals with these traps have been briefly discussed.

## ACKNOWLEDGEMENTS

We are thankful to the Director, Zoological Survey of India, for providing facilities and suggesting the topic for presentation in the Symposium. Our thanks are also due to Shri T. P. Bhattacharyya, Shri Manoj Sen Gupta and the staff of the Photography Section, for rendering their assistance in many ways during the preparation of the manuscript.



## REFERENCES

- ABRAHAM, E. V 1958. Bothered by Rats of Rice Fields ? *Indian Farming*, 7 (12) : 31-32.
- AGRAWAL, V C. 1981 Techniques for the study of rodent population. *Zoologiana*, 2 : 74-80.
- BARBEHENN, K. R. 1969. Responses of rodents and shrews to patterns of removal trapping. *Proc. Indian Rodent Symp., Calcutta*, 1966, pp. 247-252.
- BATRA, H. N. 1969. Results of rat control measures in intensive agricultural district programme. *Proc. Indian Rodent Symp., Calcutta*, 1966, pp. 139-143.
- BOURKE, D. 1925. Monkey trainers and bird catchers in Pattani, South Siam. *Indian Forester*, 51 1-4.
- FITZWATER, W D. 1969. Trapping rodents. *Proc. Indian Rodent Symp., Calcutta*, 1966, pp. 243-246.
- KIRKPATRIC, K. M. 1955. Aboriginal methods employed in killing and capturing game. *J. Bombay nat. Hist. Soc.*, 52 : 285-300.
- NAIDER, C. V B. 1962. Squirrel damage to the arecanut crop and its control. *Arecanut J.*, 13 : 91-94.
- VENKITASUBBAN, C. S. 1948. What's doing in all India : Cochin. *Indian Farming*, 9 (8) : 343-345.

## DISCUSSION

- Q. *Can you provide the names and addresses of manufacturers or distributors for the remote-triggered door traps and breakback traps described in your paper ?*
- A. We shall provide you the names of the firms dealing with them separately. However, these traps are readily available in the Calcutta market.
- Q. *Instead of giving description of the traps and success only, won't you think that it will be helpful to the participants if you illustrate those traps in your paper ?*
- A. The figures will be included in the proceedings of the workshop.

## **MAINTENANCE PROBLEMS IN OLD HISTORICALLY SIGNIFICANT COLLECTIONS : ZOOLOGICAL SURVEY OF INDIA**

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### **INTRODUCTION**

The zoological collections of the Zoological Survey of India date back from the days of the Asiatic Society of Bengal, which was founded in the year 1784 by Sir William Jones. Scientists of the present generation and of the future owe a deep indebtedness to these pioneers who thought fit to acquire, study, and preserve the valuable animal wealth of the then British India. Many of them were not professional zoologists or taxonomists for that matter like us, but took to natural history more as a hobby and out of inquisitiveness. In common with some of the other collections in the Zoological Survey of India, the Mammal collection is also one of the historically old collections of the world. Some of the specimens are more than 150 years old.

Mammal collections were made by such veterans in the 19th century as V. Ball, W.T. Blanford, H. H. Godwin-Austen, B. H. Hodgson, J. Scully, F. Stoliczka, R. Swinhoe, W. Theobald, S. R. Tickell, R. C. Tytler, J. Wood-Mason, etc. These learned men toured the length and breadth of India, Burma, the present Bangladesh, Sri Lanka and Pakistan and even beyond as far as Yunnan. The mammal collections diligently made by them were presented to the Asiatic Society of Bengal who in turn donated them to the Indian Museum. The Zoological Survey of India on being established on the 1st July 1916 by an act of the Government of India, inherited all these collections. These collections together with those procured by the Zoological Survey of India by actual collecting in the field, are now called the National Zoological Collections of India.

### **AREAS OF COLLECTIONS**

As stated earlier the acquisitions in the Zoological Survey of India range geographically from not only the main Indian peninsula, but also from adjacent countries. This was mainly possible because of the different expeditions which were organised for some political reason or whatsoever. Thus the First and Second Yunnan Expeditions in the year

1868 and 1875 under the leadership of Dr. J. Anderson brought a wealth of mammals from that area. Similarly the Persian Boundary Commission (1870—1872) made valuable collections from the Pamirs and Central Asia. The Yarkand Mission (1873—74) explored the Central Asian areas of Afghanistan and Kashmir and brought back valuable material. The Dafla expedition to the present Arunachal Pradesh (1874-75) worked in difficult terrain to collect material. In the present century, collections made by the officers and staff of the Zoological Survey of India are noteworthy. Thus the Chilka Lake Survey for Mammals in 1914 yielded much additional material. The Survey of Siju caves in Meghalaya in 1922 added some small mammals, specially bats. During the Second World War, Dr. M. L. Roonwal who was especially recruited to become a mammalogist of the department was seconded as a Major to work in the Eastern front notably in Manipur and adjacent areas of Burma. He was sent mainly to check and find out the cause of Scrub-typhus infection and the carrier believed to be a rodent specially of the genus *Rattus*. During the course of this assignment in 1945, Dr. Roonwal made excellent collections of small mammals, especially rodents which augmented the ZSI Mammal collection to a very great extent. These collections are valuable in the sense that they are from very interesting areas, zoogeographically. These collections are not “historically old” in the strict sense and hence we will not deal with them any further. However, it must be said that in respect of care and maintenance of these collections, some of the aspects discussed later apply equally.

## HOLDINGS

Thus it can be inferred from above that the entire mammalian collections which were present in the Indian Museum formed the nucleus of the Zoological Survey's mammalian holdings. This consisted of 4,872 examples which incidentally is the first ever systematic mammalian collection in India. From this small beginning, through the various acquisitions, the present possession runs to about 22,000 specimens of which about 400 are types.

## PROBLEMS OF MAINTENANCE

Before we begin to discuss the different problems associated with the maintenance of such collection, it would be interesting to trace back as to how these were stored from the beginning. The Zoological Survey of India when founded in 1916 consisted of only four or five officers who took over the entire responsibility of care and upkeep of not only the mammal collections but also of other groups of animals received from the Asiatic Society. The office of the Survey was housed on the topmost

floor of the present Indian Museum building evidently because of the close link with the Indian Museum itself. In the early part of this century steel was a rare commodity and wood being considered as sturdy and cheap and with lack of fabricating technology for steel, wood was chosen for the cabinets for keeping the collections. These cabinets made of Burma Teak have stood the test of times all these years, though they must necessarily be replaced now.

With such provisions for keeping these old collections, it is but natural the problems of maintaining them continuously over a period of more than 65 years in the Zoological Survey of India become complicated and beset with difficulties. The climatic conditions of the country as a whole, and of Calcutta in particular, the lack of air conditioning arrangements, the heat, dust, pests and the wear and tear due to handling affect the condition of the collections. We shall discuss these aspects.

India is a tropical country as is known to all, but the climatic conditions vary vastly from one area to another. The diversity is so marked that often it is said that in India one can blister in the scorching heat of the Rajasthan desert and at the same time enjoy the cool climate of the Himalayas within a few hours of flight. In general the Northern plains show extremes of heat and cold, whereas further south the climate is more or less congenial. The rainfall is also in a similar manner much varying, the eastern region as Meghalaya, Assam, and the western region as Maharashtra, Konkan, and Kerala receive a heavy share of the monsoon rains. The plains of West Bengal also have an equal share of the monsoon rains. The city of Calcutta where these collections have been housed for a number of years has the climatic picture as below :

Temperature	Summer 38.1—41.7°C, March—May Winter 9—36°C, January—Feb.
Rainfall	1581 mm (NE Monsoon, June—September)
Humidity	60—90 %

It will be seen that the temperature and relative humidity are highest in summer months and comparatively low in winter months. This variation in the temperature and humidity in turn impinges on the collections, even though they have been kept covered under glass topped wooden drawers. The resulting loss of fur or hair due to drying up of the specimen, discoloration and finally tendency to become brittle are the effects of such climatic variations.

The collection is housed in a busy centre of the city, opposite a huge marketing complex. The wooden cabinets already being heavy because of their being made of Burma teak and coupled with the contents of mammal-skins, bones, skulls, etc., have perforce necessitated their

being kept just above the ground level, on the first floor. This being very near the main street unlike the other collections which are further up in the same building, the chance of dust entering the floor where these are kept is greater. Further when these collections are taken out for regular maintenance, or for research purposes, they are immediately exposed to outside dust, the periods ranging from a few minutes to even some days depending upon the nature of the requirements for which they have been pulled out. These minute dust particles consisting mostly of fine sand grain, soot, carbon from the exhausts of passing automobiles settle in between the hairs of the skin and body of these specimens. Those ultimately cause erosion and the skin gets crack or even torn at places.

The trays or drawers containing these collections are protected from pests by putting naphthalene and paradichlorobenzene in them. The vapour emanating from these chemicals are not very strong, but help to keep the collections free from insect pests, cockroaches, etc. However, these repellants do effect the collections as a whole. The major effect of these chemicals is the loss of colour.

The handling of the collections is a must since they are meant for only such research investigations. Handling is done manually and no mechanical device is designed. Where a large number of examples or boxes are to be moved, some trolley-trays are used, but even here loading of these is done manually. The step in examining the specimens such as unpacking, re-measurements, photographing, dusting, etc., all cause some damage or the other, though it is slow and cumulative, depending upon the number of occasions a particular lot is handled. These often cause brittle parts, loss of original shape and size, and direct exposure to climatic conditions like heat, dust, etc.

#### REMEDIAL MEASURES

It is obvious that for keeping these collections, climate controlled condition is a necessity. With a laboratory complex where collections are kept under such controlled condition, at one sweep the problems of dust, heat, humidity, etc., would be minimised. The collections should be segregated from the working place so that they are least affected by dust generated by movements of personnel. The cabinets of wood can be replaced by steel ones. If the same are kept under climate-controlled conditions rusting would be minimal. Plastic trays, could be utilised for keeping collections. Already the types are segregated and this should be continued. A single booster dose of fumigant or pesticide which would protect the entire holdings in toto should be adopted instead of individual or piecemeal treatment.

The Zoological Survey of India is getting its permanent ten storied building and we intended to adopt these measures for the protection of these collections. But keeping in view the costs, and also the fact that the Survey has to cater to all its sections and not only to mammals, it may not be possible to achieve the ideals as one would wish to have. A beginning is being made and we hope during the course of successive years these collections would receive the protection, care, and maintenance they richly deserve.

### SUMMARY

In common with most collections in the Zoological Survey of India the Mammal collections also date back to historical times as far back as 1784. The bulk of the collections have been derived from the Asiatic Society of Bengal who in turn handed over their possessions to Indian Museum in 1875. The Asiatic Society received valuable collections from the First (1868) and Second expeditions to Yunnan under the leadership of Col. J. Anderson, the Persian Boundary Commission (1870-72), the First and Second Yarkand Missions and the Dafla Expedition (1874-75). Beginning from small number of 1330 examples received from the Asiatic Society, the holdings of the mammals in the Zoological Survey of India now stand to about 22000 specimens including about 400 types.

Maintenance of the old collections pose several problems especially in a tropical environment and more particularly in a humid city like Calcutta. Added to the deprecations of climate, the damage due to handling for research, for maintenance, for routine curatorial works as change of labels, preservation, addition of information data, transit to loan/exchange parties, pest control measures and effect of pesticides themselves are significantly problematic. Keeping in view of the fact that in a large developing country as India where manpower is to be judiciously maintained and used unlike in advanced countries where mechanical means are utilised, the problems of management becomes complicated.



**MAINTENANCE PROBLEMS IN OLD, HISTORICALLY  
SIGNIFICANT COLLECTIONS OF MAMMALS :  
ZOOLOGICAL REFERENCE COLLECTIONS OF  
THE NATIONAL UNIVERSITY OF SINGAPORE**

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**INTRODUCTION**

The Zoological Reference Collection holds about 140,000 identified reference specimens that represent research work carried out over the whole history of the former Raffles Museum (now the National Museum of Singapore), which was established in 1820. The collection also includes reference materials of the former Federated Malay State Museums. The collection was housed in the museum building until it was transferred to the National University of Singapore in 1972. It is now stored temporarily on the campus of the Nanyang Technological Institute in Jurong and is being curated and maintained by six museum staff members.

The collections have been gradually built up by donations, purchases, contributions, and many collecting expeditions in Indo-China, Thailand, Malay Peninsula, Borneo, Sumatra, Java, and other areas of Southeast Asia since its establishment. It is now a historical record of the animal life of this region as a large proportion of the specimens were collected in places where the natural habitats have been completely destroyed. Some of the species represented have become endangered species and are protected by law.

Out of the total of 140,000 specimens in the collection, 14,300 specimens are mammals. These belong to 41 families, 130 genera, 315 species, and 771 subspecies (Yang and Chou, 1985). The majority of these specimens have been described or listed by Robinson, Kloss, Chasen, and others (Chasen, 1940; Jones and Jones, 1976).

**STORAGE**

The majority of the mammal specimens are preserved dried as skins, skulls, or mounted materials, but a small number of bat specimens are



preserved in 75% alcohol. The dry and wet materials are stored in separate rooms. According to the size and nature of the specimens, they are kept in various types of storage equipment.

#### *Large-sized specimens*

Large specimens such as elephants, tapirs, gaurs, wild pigs, malaysian bears, and orang utans are mostly preserved as flat skins (folded or rolled) and a few are as mounted specimens. These bulky specimens and their big skulls are stored in huge wooden boxes with sizes varying from 120 cm W by 140 cm D by 110 cm H to 250 cm W by 90 cm D by 80 cm H (Fig. 1).

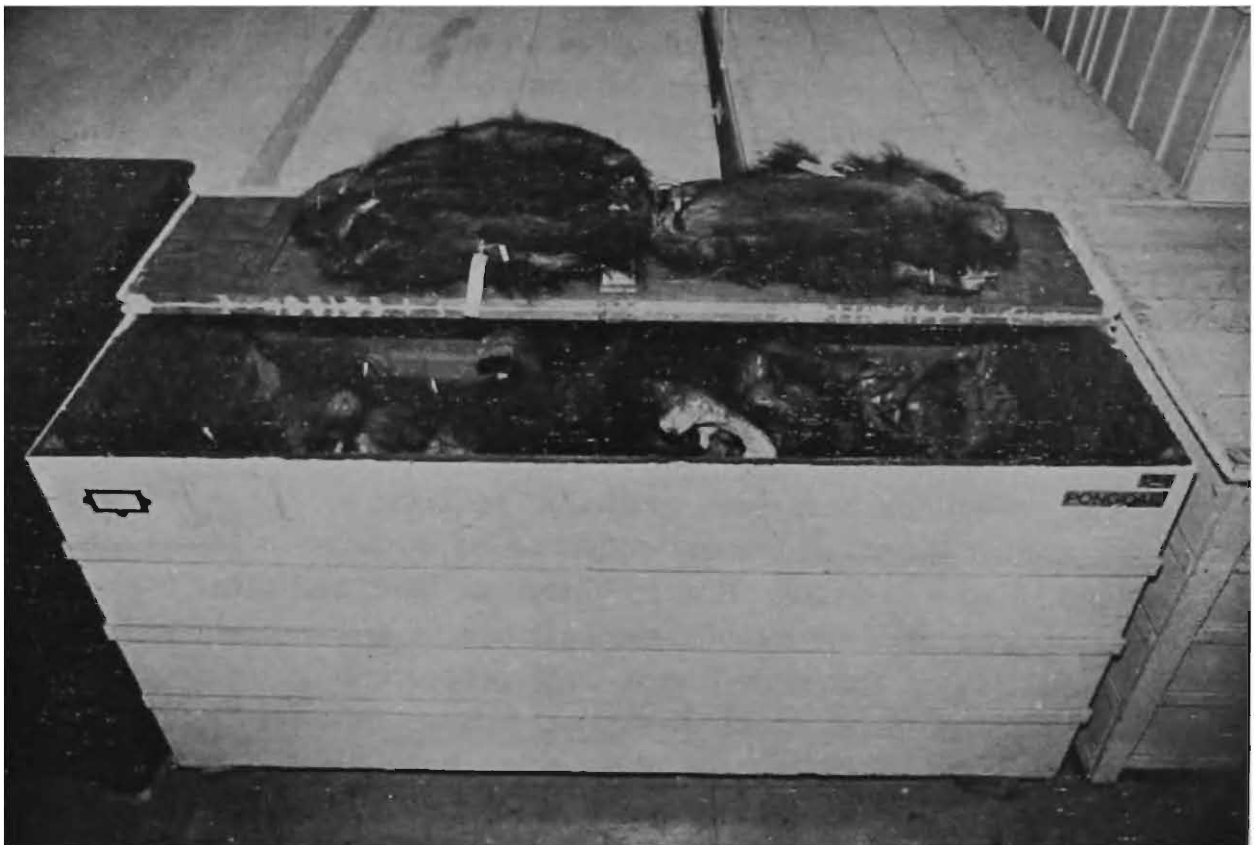


Fig. 1. Storage of large-sized specimens in wooden boxes.

#### *Medium-sized specimens*

Skins, skulls, and mounted specimens of monkeys, gibbons, porcupines, giant squirrels, carnivores, mouse deer, and other medium-sized mammals are stored in medium-sized wooden boxes ranging from 40 cm W by 90 cm D by 30 cm H to 90 cm W by 120 cm D by 30-50 cm H. They are piled from two to five boxes in a stack. Each box is fully packed with specimens, sometimes as many as 50 (Figs. 2 and 3).



Fig. 2.—Storage boxes for medium-sized specimens in wooden boxes.

### *Small-sized specimens*

Smaller specimens like rats, squirrels, shrews, tree shrews, and bats are stored in glass-topped boxes of three different sizes 18 cm W by 90 cm D by 12 cm H, 18 cm W by 44 cm D by 12 cm H, and 18 cm W by 38 cm D by 6 cm H. These glass-topped boxes are placed in the drawers of wooden cabinets, about 120 cm W by 100 cm D by 170 cm H in size. Each cabinet has eight drawers; each drawer can hold six big glass-topped boxes (Figs. 4 and 5).

The majority of these small-sized specimens are prepared as round skins, some as flat skins. The skulls are placed in plastic or glass tubes and stored together with their skins.

### *Fragile specimens*

The specimens of flying lemurs were formerly overlapping each other and packed in the medium-sized storage boxes. Because these flying lemurs are preserved with their flying membranes stretched out, their brittle and delicate flying membranes are easily damaged.

In recent years, a new type of wooden cabinet has been constructed for storing these flying lemurs as well as other fragile specimens which are not in good condition. The cabinet is 123 cm W by 71 cm D by 107 cm H in size; they are reasonably dustproof and airtight. These cases hold a maximum number of 40 small trays (53 cm W by 65 cm D by 5 cm H) or 20 big trays (110 cm W by 65 cm D by 5 cm H) (Fig. 6). All trays are interchangeable and adjustable. The specimens are placed in a single layer on the tray so as to give them better protection and to avoid unnecessary handling of these fragile specimens. The skulls are kept together with the skins.



Fig. 3.—A box of proboscis monkeys, skins and mounted specimens stored together.



Fig. 4.—Storage cabinets, each with eight drawers for small-sized specimens stored in glass-topped boxes.



Fig. 5. Glass-topped boxes for storage of small-sized specimens.



Fig. 6.—Wooden cabinets with adjustable trays for storing fragile specimens such as flying lemurs.



Fig. 7. – Storage cabinets for larger skulls and skeletons.

*Skulls and skeletons*

Bigger skulls of carnivores, ungulates, and other large mammals are stored in wooden cabinets of 168 cm W by 76 cm D by 193 cm H. Each cabinet has 12 drawers of 75 cm W by 70 cm D by 26 cm H in size (Fig. 7). Skeletons are also stored in these cabinets. The small skulls are either kept in small cardboard boxes, glass tubes, plastic containers, or plastic bags to prevent loose teeth or bones from being mixed up. These small skulls are stored with their respective skins in the same box.

*Wet specimens*

Some of the bats and other miscellaneous specimens are preserved in 75% alcohol in glass jars. A layer of grease is applied on the glass covers to prevent evaporation of the alcohol from non-airtight jars. Specimen jars are stored on steel erected shelving (91 cm W by 61 cm D by 200 cm H) (Fig. 8).



Fig. 8.—Storage of wet collection on open shelves.



Most of the wet materials are preserved whole with their body contents and skulls. Some of the bats are preserved with only the body, their skulls have been removed and stored as dried materials.

### *Type specimens*

Type specimens are stored separately from the non-type materials so as to give special attention for curating and maintenance. They are stored according to their sizes in various types of storage equipment as discussed above.

## LABEL AND ARRANGEMENT

All the specimens, either preserved dry or wet, have a label tag with catalogue number and all relevant data. The specimens of the same taxon and locality are placed in the same container wherever possible. Each container has a label with the name of species, number of specimens, and locality.

All type specimens have coloured tags and labels to differentiate them from ordinary specimens. The holotypes are in red, paratypes in yellow, and syntypes in green. Blue is used for topotypes.

All specimens are arranged systematically according to their classification up to family level, whereas genera, species, and subspecies are arranged in alphabetical order. Specimens of a subspecies are arranged according to locality, country, and geographical range.

## MAINTENANCE AND PROBLEMS

### *Housing and storage*

Since the transfer of the collection from the National Museum to the National University of Singapore, it had been shifted three times in the last 10 years as there was no permanent housing provided to accommodate the collection. The shifting has done some damage to specimens, especially to those old, fragile, and large mounted specimens.

The collection is now temporarily housed at the Nanyang Technological Institute Library Building, occupying a floor area of 600 m<sup>2</sup> of which mammal occupies about 190 m<sup>2</sup>. Because the housing space is inadequate, all specimens have to be packed and overlapped in the storage cases. The storage cases have to be piled several boxes high in a stack. Furthermore, most storage boxes are a century old and they are

neither airtight, dust proof, nor vermin-proof. Therefore, intensive labour is involved in checking and maintaining the collection.

The shortage of storage area has not only caused inconvenience for examination and maintenance, but also caused damage to the specimens. During examination or routine inspection of specimens, they have to be removed one by one from the boxes. Some skins are stored together with mounted specimens which have their limbs or tails expanded and easily become entangled with other specimens (Fig. 3). All of these have caused the specimens to be damaged easily. Frequent handling or careless handling has done a considerable amount of damage to the specimens, especially if users are in a hurry to examine the materials in a short period of time.

Improperly prepared specimens are more easily damaged than others. Some of these specimens have no proper physical support for heads, limbs, and tails, others have rusty wire which breaks easily.

#### *Humidity and temperature*

At present, the collection is housed in a non-air-conditioned building. Therefore, the temperature and humidity of the environment of the collection storage area fluctuates day and night throughout the year. The temperature ranges from 23°C to 35°C while the relative humidity from 60% to 97%.

Because moulds will grow rapidly in a high humidity environment and because the preservatives, insecticides, and fungicides will evaporate faster at higher temperatures, the periodic inspection for moulds, pests, and preservatives are carried out at intervals of 4 months. During the rainy season (from October to January), the dry specimens are inspected about once every 2 months. The wet specimens are checked about once every 6 months for topping up the preservative.

Dehumidifiers are used in the collection storage area every night to reduce the humidity in the room. The room is opened for ventilation during daytime.

#### *Control of moulds*

Moulds are not only found on the skins and skulls but also on the wooden boxes and cabinets, especially their joints. Skins that are not well prepared (for example, oily) are more frequently found to be mouldy. Brushes and mini vacuum cleaners (12 volts) are used to remove moulds from the specimens, boxes, and cabinets; at the same time dust is also removed. Those mouldy specimens are treated on the affected parts



with 5% carbolic acid. Acetone and a solution of 5% formalin was found to be not as effective for the treatment of mouldy skins. Mouldy skulls and skeletons are washed if necessary and sun-dried, and finally treated with 10% formalin.

Mouldy cabinets and boxes are treated with 30% formalin. Solutions of 10% and 20% formalin were tested but were found to be not effective in killing spores in joints or gaps of wooden cases.

### *Control of pests*

Pest infestation does not cause any major problem in the collection. At present, the pests found in the collection are mainly cockroaches and silverfish. They are brought under control by using Baygon insecticide. Napthalene is used as an insecticide in all storage boxes and cabinets. To prevent crystals from appearing on the specimens, the napthalene is wrapped in cotton wool before being placed in the boxes. Periodic checks at intervals of about 4 months are carried out to ensure a continuing supply of napthalene.

Although paradichlorobenzene and vaponal are effective insecticides (Wagstaffe and Fidler, 1968; Williams *et al.*, 1977; Edwards *et al.*, 1981), they are hazardous to museum workers. We found that napthalene is safer, effective, and an inexpensive insecticide to use in non-airtight storage containers.

All incoming specimens are fumigated before placing them into the collection. New boxes or cabinets and all other materials, for example, cloth, paper, cotton wool and others are treated with a mixture of 1 part chloroform, 1 part carbolic acid, 4 parts petrol, and 6 parts napthalene before usage.

### CONSERVATION AND REPAIRING OF SPECIMENS

If during routine checking damaged specimens are found with broken limbs or tails, they are immediately repaired. Bracing or bandages, some with extra support, are applied to the damaged specimens (Fig. 9). Loose teeth or bones are glued into position. Due to easier damage to the old and brittle specimens while handling, all medium-sized specimens and large skins and skulls are placed in plastic bags so as to give extra protection against dust and to avoid careless handling (Fig. 10). Skins that are beyond repair are wrapped with cloth and placed in plastic bags. Holes are punched in the bags for air ventilation. Damaged or brittle labels are either sealed with 3M Scotch Magic Transparent Tape No. 810 or with plastic bags. A new label with all relevant data is added to specimens that have a torn label.



Fig. 9.—Repairing of damaged specimens.



Fig. 10.—Specimens repaired and placed in plastic bags to give added protection and support.

## CONCLUSIONS

Mould is the most serious problem for maintaining the zoological collection in this humid tropical environment, but it is under control by routine inspection and treatment with fungicides and insecticides. Although the collection is now housed temporarily in an inadequate area, an area of about 1000 m<sup>2</sup> in two stories in the Science Library Building on the new National University of Singapore campus has been allocated to accommodate this collection. The new building is expected to be completed in 1985. The following facilities have been proposed for housing the collection: (1) dry and wet collections to be stored on separate floors; (2) 24 hour air-conditioning at 20°C temperature and 50-55% relative humidity; (3) provision of a movable compactor storage system, which is airtight, dustproof, and vermin-proof; (4) storage cabinets with adjustable trays; all specimens will be arranged on a single layer and will not be overlapping.

Under the above housing and storage conditions, specimens will be free from moulds, pests, and dust. They can be easily examined and unnecessary handling will be avoided. Therefore, specimens which are brittle or have been damaged will not deteriorate further.

## SUMMARY

The zoological reference collection has its origin from the former Raffles Museum collection, which was established in 1820. Presently, the collection has a total of about 14,300 mammal reference specimens primarily from Southeast Asia. The majority of the specimens are preserved dried, whereas a small number are stored in 75% alcohol. The wet specimens do not present much problems, but considerable care has to be taken for the dried skins and large mounted specimens. Because of inadequate storage area, uncontrolled temperature and humidity of the building, non-air-tight, non-vermin proof storage boxes and cabinets, and related problems, the collection faces more maintenance problems especially to the old and brittle specimens. Methods of storing, preserving, and maintaining this historical collection are discussed.

## REFERENCES

- CHASEN, F. N. 1940. Handlist of Malaysian mammals. A systematic list of the mammals of the Malay Peninsula, Sumatra, Borneo, and Java, including the adjacent small islands. *Bull. Raffles Mus.*, **15** : 1-209.

- EDWARDS, S. R., BELL, B. M. and KING, M. E. (eds.). 1981. *Pest control in museums : a status report (1980)* : 1-34. The Association of Systematics Collections, Lawrence, Kansas.
- JONES, G. S. and JONES, D. B. 1976. Bibliography of the land mammals of Southeast Asia, 1699-1969. *Spec. Publ., Dep. Ent., B. P. Bishop Mus.*, : 1-239.
- WAGSTAFFE, R. and FIDLER, J. H. 1968. *The preservation of natural history specimens*. Vol. II : 1-404. H. F. and G. Witherby Ltd., London.
- WILLIAMS, S. L., LAUBACH, R. and GENOWAYS, H. H. 1977. A guide to the management of Recent mammal collections. *Spec. Publs., Carnegie Mus. Nat. Hist.*, 4 : 1-105.
- YANG, C. M. and CHOU, L. M. 1985. The mammal collection of the Zoological Reference Collection, Department of Zoology, National University of Singapore. *Acta zool. Fennica*, 170 : 54-56.

#### DISCUSSION

- Q. *Plastic bags protect the specimens from dust nicely but how do you remove the possibilities of reaction of plastic with different chemicals used in maintenance work ?*
- A. There are possibilities but at present we do not have these problems.
- Q. *Do you have any trouble with condensation inside the plastic bags in which skins are stored ? What about inside glass-topped boxes ?*
- A. We do not have any condensation trouble with plastic bags or glass-topped boxes.
- Q. *Have you any idea about side effects due to formaldehyde fumigation or have you noticed any side effect in your own collection ?*
- A. There is possibility of side effects but I have not noticed any side effects in our collection yet.



## **THE NEED FOR POPULAR NATURAL HISTORY PUBLICATIONS CONCERNING MAMMALS**

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### **INTRODUCTION**

The level of environmental education found within the boundaries of any particular country varies greatly throughout the world. Disparities in formal and informal training in conservation biology or natural history may be as great as those characterising gross national products. Education is a multifaceted enterprise that acts at all levels of society. It encompasses formal education in the school systems, as well as public education which does not occur in a classroom situation. Generally, grade schools, high schools, and universities are the primary agents of formal education, whereas public education, or education of the masses, is a much more diffuse endeavour. Public education utilises a large number of avenues for access to its audience, such as newspapers and other print media, radio, television and films, posters, books, lectures, and various other elements of communication of present-day societies. Among the very important contributors to public education in environmental biology and natural history are the many science and natural history museums of the world. Each year these museums, through their public and professional activities, are responsible for bringing accurate information about nature and man's place in his natural world to an audience of tens of millions of lay people. Not only are museums charged with presenting varied topics on nature to the public, but they must do this in such a way that their audience must be sufficiently attracted to the museum to want to stay and learn, and may even have to pay for the privilege of visiting the museum. Accomplishing the educational mission of the natural history museum in a society that may not value the role of the museum sufficiently to offer adequate financial support to the organisation is a constant challenge to museum directors, curators, and other museum professionals.

We can view the educational operations of a natural history museum as having various components that interact with all levels of society. These interactions can either be active or passive, with active programmes being those that reach out to the public in an intensive and very effective manner (discussed below). Natural history museums often contain a number of extensive systematic collections. The collections are, of course, the very heart of the museum, forming the backbone of all museum operations.

Whether the collection is one of fossils, insects, birds, or mammals, it is the basis for exhibits, publications, teaching programmes, and research.

In this paper I will examine some of the educational operations of a single part of a natural history museum, the collection of mammals. In some organisations, a mammal collection may in effect be the entire museum, whereas in larger museums the collection forms a small part of the broader museum operation. Nevertheless, educational programmes associated with mammal collections mirror the function of the overall museum. I will first discuss how mammal museums (or mammal collections) interact with society, and will then focus on one aspect of museum operation that I believe is critical to the effectiveness of the overall educational programme—the production of popular literature dealing with natural history.

#### MAMMAL MUSEUM OPERATIONS

A museum is a synergistic organisation deriving its effectiveness from interactions among its components. In a sense, each component reflects the overall mission of the museum. Thus, considering how a mammal collection functions lends some understanding to general museum operation. More important, increasing the quality and diversity of mammal collection operations should lead to more effective programmes in general, since not only is the general museum programme synergistic, but education of the public is also a synergistic activity. Fire the interest of the public in mammalian biology and they will wish to know more about birds, reptiles, fossils, and the like.

Figure 1 illustrates the varied educational programmes of a museum or collection. Note that programmes may either be active or passive. Passive programmes generally involve the most basic museum activities, such as collection development and preservation, exhibit design, and resident expert advice. In such activities, the audience generally comes to the museum and learns passively, whether walking through an exhibit or asking a curator to identify an animal. Passive programmes range from the expensive (exhibits) to the inexpensive (expert advice). They may affect the general public, or may have professional biologists or government bureaucrats as the primary audience. Passive programmes that affect the general public, such as exhibits, are designed in such a manner that a person spends as much, or as little, time as he desires with the exhibit.

Active educational operations generally deal with a more select audience. This type of educational activity often demands much staff time and may also be monetarily expensive. However, learning in the



Fig. 1.—The diverse functions of natural history museums, noting especially the distinction between “passive programmes” which appeal to a broad audience (General Public, Government Officials, and Professionals in museum subjects), and “active programmes,” which are primarily intended for the General Public. Active programmes require extra efforts by museum professionals, yet these very programmes may have the most far-reaching impact of all museum operations as far as real education is concerned.

target group is likely to be much more intensive. An in-house programme, such as a curator lecture series, for example, may reach only small groups of people, but a well-illustrated and inspiring presentation can teach people much about the subject in question. Outreach programmes, such as travelling exhibits shown in schools and accompanied by a museum professional, can have a direct impact on children’s education in natural history.

It would be instructive to examine how these programmes operate in an actual museum setting, but such a discussion is beyond the scope



of this paper. What I will concentrate upon in the rest of this paper is the third type of active educational activity—publications.

### MUSEUM PUBLICATIONS

Museums produce numerous kinds of publications, from pamphlets to books and scientific journals. Basically, however, publications are either designed for a professional audience or for the general public. It might at first appear that technical and popular publications are independent of one another, but this is probably not so. As Mares (1982) and others have argued, technical publications are the basic data for popular publications. The reasons for this are as follows.

As a country develops its cultural and scientific identity, there seems to be a comparable pattern of development of a societal awareness of natural history. Interest first begins in cataloguing the floral and faunal resources of the country. The first step in this process is a complete survey of the country's biota, particularly (for economic reasons) in the areas of woody plants and vertebrates. The data that accrue as a part of any survey are fundamental data on taxonomy, macro- and microdistribution, and general natural history. As these foundational scientific papers are published, they become available to the scientific community and to those few people who act as an interface between the scientist and the general public—the authors of field guides and other types of publications intended for education of the public.

All field guides owe their existence to the basic research done by numerous biologists who are often only capable of communicating their findings to an audience of specialists. As the number of specialised investigators increases, there is a small number of them who can write with sufficient clarity and who will dedicate the time necessary to synthesise the technical literature and present it in a form that is usable by a wide audience of non-scientists. Such semi-technical literature can have a broad influence on society by interesting the public in various aspects of their environment. Mares (1982) has examined how mammal literature in the United States developed over a span of about 75 years. Beginning with the faunal survey work of C. Hart Merriam and his team of investigators from the U.S. Department of Agriculture in the late 1800's, the literature of mammalogy proceeded through a technical phase into a popular one that began on a large scale in the 1950's.

The relationship of basic research to the literature of mammalogy is shown in Figure 2. Both technical and popular literature begin with basic survey work. As the results of survey research are published there is an increase in the scientific literature. This increase occurs not only

because the survey results themselves are being published, but because as they are published other scientists pursue questions that can only be formulated after the basic survey results have been obtained. For example, a basic taxonomic study showing that a taxon thought to have been a single species is actually a multispecies complex might very well ultimately lead to studies examining niche relationships, comparative physiological research, genetic relationships, or speciation patterns. All research of this type can only be designed after basic survey work has clarified species relationships and distributional patterns.

All of the technical literature comprises the foundational literature for semi-technical works such as field guides, just as the survey research publications proved foundational for much of the technical literature. Technical research publications have little direct impact on the educational level of the general public. Such literature is often published in obscure journals and frequently involves a specialised jargon. Moreover, such literature is written with little concern for the palatability of the prose. Thus, even if technical literature were widely available to the public, it would probably not be read. Semi-technical literature, therefore, serves as a bridge between the scientific establishment and the more-educated general public.

Field guides and their ilk have direct effects beyond their impact on the general public, however. They serve to bring broadly synthetic material to the scientists, themselves, and thereby increase scientific awareness and activity. Imagine, for example, a specialist in rodent taxonomy working in South America. South America has a remarkably complex fauna and a specialist on one taxonomic group may be very poorly versed in another group of mammals. A field guide could thus bring together disparate data in a format that would be quite useful to specialists such that their taxonomic sophistication is significantly elevated. Such a pattern is seen again and again in the use by ornithologists of field guides to the birds of particular regions with which they have limited familiarity.

There is another very important role for the semi-technical publications, however, and that is serving as the bridge between the scientific literature and the numerous authors who produce the popular literature on nature that is intended for the widest possible audiences of adults and children. This very extensive literature may range from children's stories about a particular species, to general stories reviewing adaptations, to comic strips whose message is centred on some aspect of natural history. This literature is the true educator of the masses, and it may well prove to be a keystone in the development of public awareness about nature. It is this most basic non-technical literature, which may be presented merely as colouring book for children or as anthropomorphic accounts of wild animals, that introduces a great number of children and adults

to their natural environment. Thus, the child who has grown up reading about a supposedly humanised and friendly rabbit or deer is more likely to be receptive to ideas concerning conservation of wild creatures, while being more sensitive to practices that potentially disrupt natural communities. Nobody wants to kill Bambi !

Without a clear public awareness of nature, there can be no conservation ethic developed within a society. Greater public awareness may be manifested by more people deciding to enter the natural sciences. After all, most scientists are drawn from the pool of citizens comprising the scientifically aware portion of society. Equally important, public awareness may take the form of increased monetary support for research and education, as well as increased moral support by the public for the work of the scientist. It must be kept in mind that government bureaucrats, university administrators, administrators of elementary schools, business leaders, journalists, and other influential citizens are drawn from this same pool. The views of this segment of society concerning mammalogy, ornithology, conservation and other topics related to museum work are largely formed by obtaining scientific information that is presented in a popular format, whether through story books, television, newspapers, magazines, comic strips, or movies. The actions of these citizens impact directly on museums, and on the various subdisciplines of field biology.

The model presented in Figure 2 is obviously a very simplified representation of what is, in fact, a highly complex relationship. There are three major links in the figure : technical literature—semi-technical literature—popular literature. Basic survey research initiates the process, and increased public awareness of nature with effective action to deal with environmental problems and to support science (i.e., a conservation ethic) is the culmination of the model. There are numerous feedback mechanisms within the model that are operating at any one time, however, and their magnitude may vary over time. Thus a particularly effective and popular book may have an abrupt influence on public attitudes and scientific awareness. Rachel Carson's "Silent Spring" (1962) was such a work, having a seminal effect on how environmental deterioration is viewed today by the society of the United States. Paul Ehrlich's "Population Bomb" (1968) is another popular publication that had a pervasive effect in the United States on current views concerning population growth. It is doubtful, however, that either of these books would have had such wide acceptance by the public if highly influential semi-technical works such as Peterson's (1934) field guide to birds (and subsequent and related publications) had not been published years earlier in massive printings that reached millions of citizens. It is no accident that in the dramatic opening paragraphs of Carson's (1962, p. 14) "Silent Spring" was written the following description :

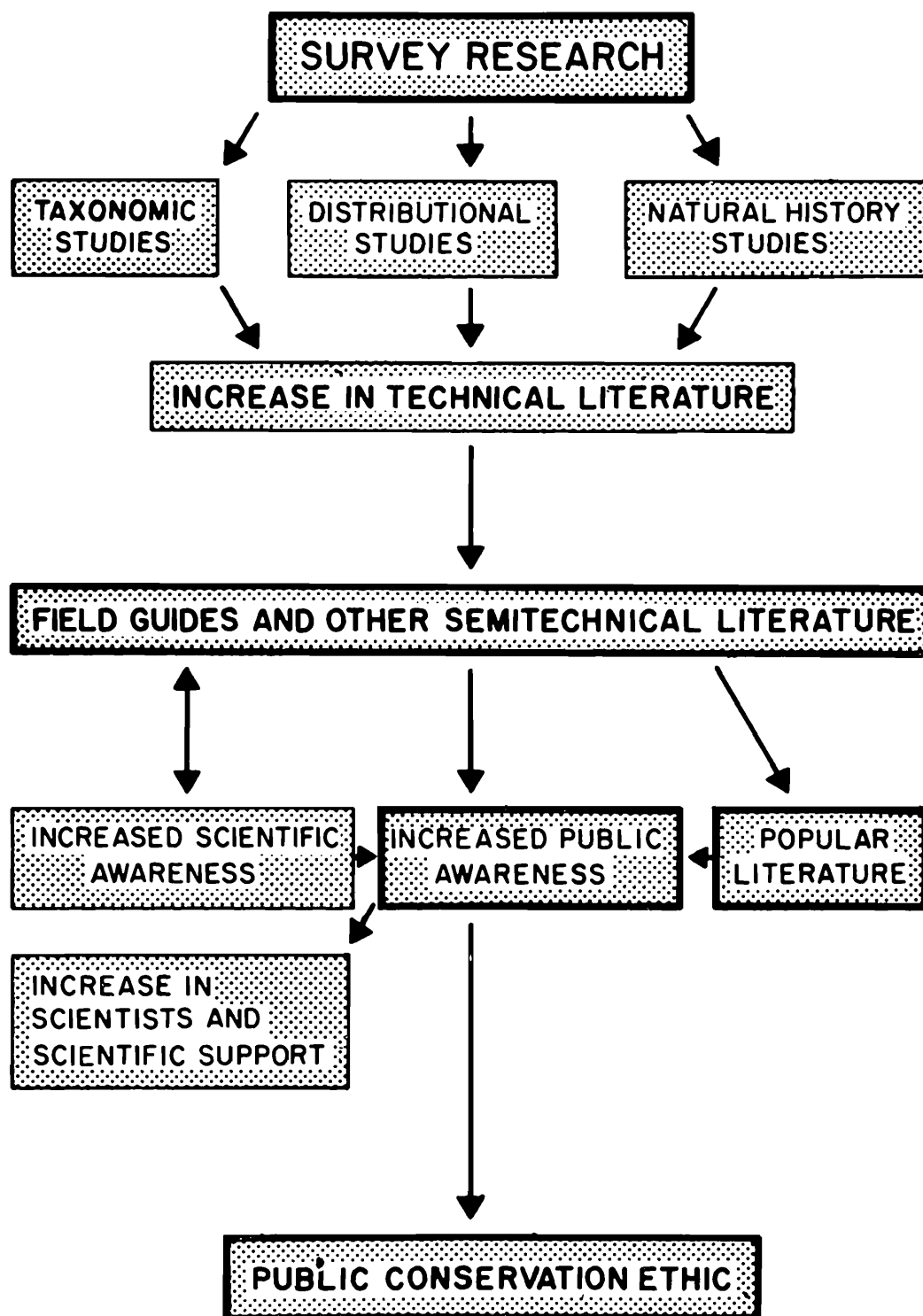


Fig. 2.—A flow chart showing the relationships between basic survey research and the development of a societal conservation ethic, via various types of publications. Note especially that basic survey research leads to an increase in the technical literature of natural history, which directly affects the availability of the semi-technical literature. The latter is directly related to both scientific and public awareness of nature and to the availability of popular literature. All interact to develop a public conservation ethic.

“There was a strange stillness. The birds, for example—where had they gone? Many people spoke of them, puzzled and disturbed. The feeding stations in the backyards were deserted. The few birds seen anywhere were moribund—they trembled violently

and could not fly. It was a spring without voices. On the mornings that had once throbbed with the dawn chorus of robins, catbirds, doves, jays, wrens, and scores of other bird voices there was now no sound; only silence lay over the fields and woods and marsh."

These words struck directly at a sensitive chord in the psyche of the population of the United States. Carson used the widespread interest of the populace in birds and birdwatching to dramatise the effects of uncontrolled use of pesticides. The book proved a landmark in stimulating additional research on pesticides and in leading to laws to control environmental pollutants.

The Peterson field guide series is another good example of how complex the links in Figure 2 may be. The original Peterson guide to birds was published in 1934. The first printing sold 2000 copies within one week and was reprinted repeatedly thereafter (in several new editions). More than two million Peterson guides to eastern U.S. birds have been sold in the intervening 50 years, with another million field guides to western U.S. birds sold also (Graham, 1980). However, in addition to their tremendous individual success, the Peterson bird guides led to field guides being published for other disciplines. Guides to birds were followed by guides to shells, butterflies, mammals, rocks and minerals, European birds, animal tracks, ferns, trees and shrubs, reptiles and amphibians, wildflowers, stars and planets, insects, birds of Mexico, birds' nests, edible wild plants, and the atmosphere ! More important, the remarkable financial success of these field guides led to the development and publication of many other guides dealing with diverse topics of the natural world and differing in style and format from the original guides (Fig. 3). Thus, the synergistic relationship of the feedback points illustrated in Figure 2 is clear. Field guides to one group of organisms stimulated the production of many other field guides to a vast array of organisms and aspects of the natural world.

#### THE NEED FOR FIELD GUIDES IN MODERN SOCIETIES

Given the fact that field guides and other semi-technical publications are integral components of the public's awareness of nature, it is instructive to examine the availability of these materials in the world. In 1981, I sent a short questionnaire to mammal collections throughout the world. The questionnaire dealt with the availability in the country of publications dealing with faunal surveys, taxonomic keys, field guides and children's literature on mammals. Moreover, the language of publication of these materials was also requested. I have summarised the initial results elsewhere (Mares, 1985), and a more detailed paper has been published (Mares and Braum, 1986). However, a few points are of

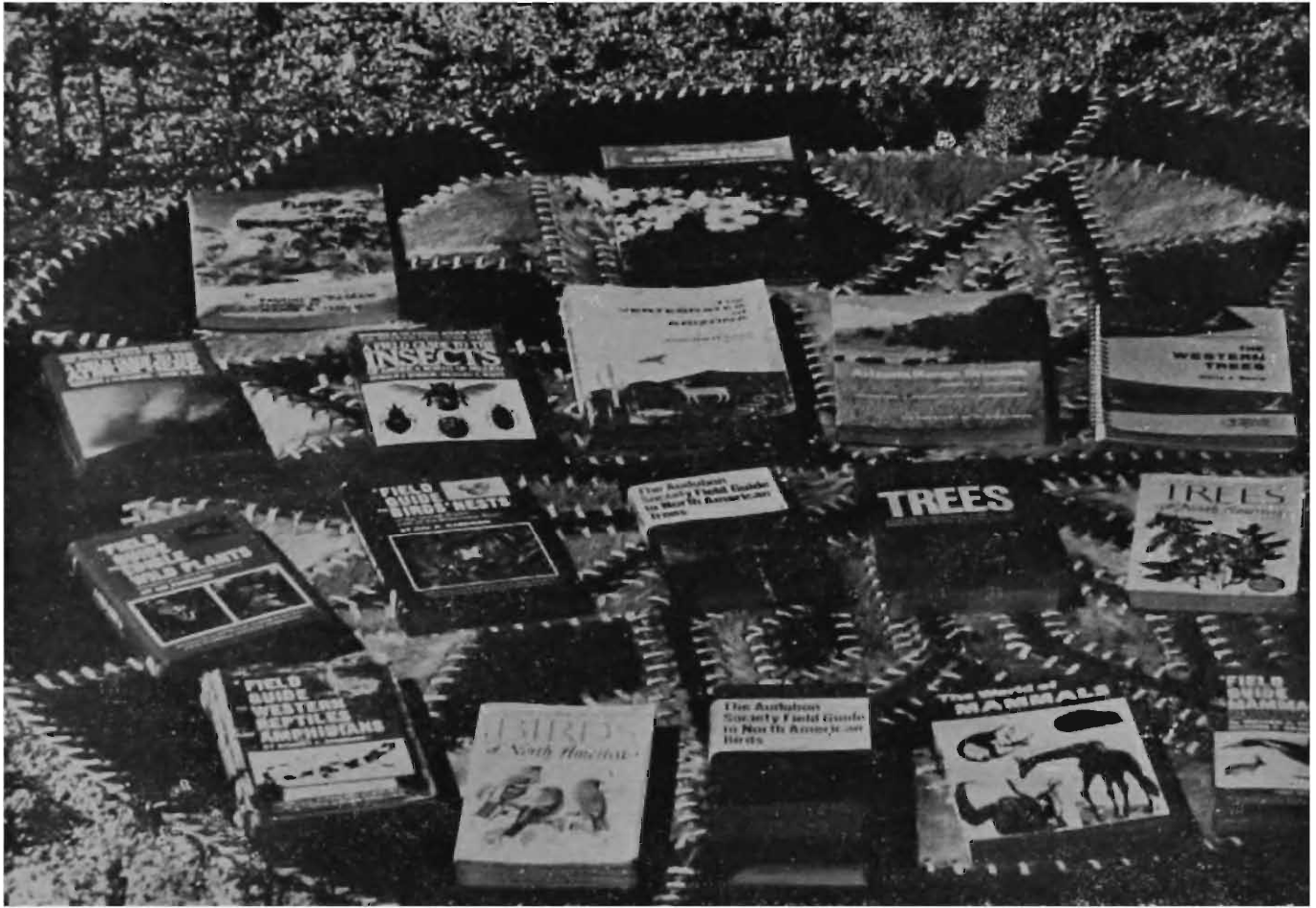


Fig. 3.—An example of the great diversity of field guides available in the United States today. The above guides were purchased at a single bookstore in a small city (Tucson, Arizona) in the western part of the country. Similar guides are readily available in almost all cities and towns of modest size or larger throughout the country.

interest here. Results from 56 of 74 countries queried indicate that the United States, Canada, Europe, Australia, New Zealand and South Africa have a strong literature in mammals at all levels, popular through technical. For most of the world, however, and particularly for South America and most of Africa, one or more of the key components shown in Figure 2 are lacking. Many countries that appear to have a strong literature have few published materials available in the common language of the country. Throughout Africa, for example, published materials are either in English, French, or German. Few or no materials on mammals exist in any African language. Below I will examine the literature situation in two countries, the United States and Argentina. I choose these countries because I have worked and lived extensively in both, and because they are at different stages of development concerning the role of literature on nature in the formulation of an environmental ethic.

## ENVIRONMENTAL AWARENESS IN THE UNITED STATES

In the United States, we have what is perhaps the most developed society from the point of view of mammalogical studies. The American Society of Mammalogists (ASM), a professional organisation of mammalian biologists that today boasts more than 3,000 members and publishes the internationally known "Journal of Mammalogy", was founded in 1919. A major driving force in the formation of the society was Dr. C. Hart Merriam, who had initiated the biological inventory of the United States in 1885 (Osgood, 1943). By 1940, Merriam and the biologists he trained had collected over 136,613 mammals in the United States, Alaska and Mexico, representing most of the known species and subspecies in the region. Their published works were extensive and included the remarkable series of monographs published under the series title, "North American Fauna". These detailed monographs on systematics and natural history provided foundational data on most taxonomic groups of U.S. mammals, as well as many state surveys.

By the time the ASM had formed, the United States had been well surveyed from the standpoint of its flora and fauna. The foundation had been laid for the scientific edifice that was to be constructed. In addition to the large collection of mammals in the U.S. National Museum, and those in other private museums, the early 1900's saw the establishment and development of several university museum collections that were used in research and teaching, particularly graduate education. Early curators of university museums often published both scientific and semi-technical works, and such activities were continued throughout the 1900's. More important, a few of these university mammalogists established extensive graduate programmes—programmes which not only produced more mammalogists, but larger and more complete collections. As the number of mammalogists increased dramatically, they were no longer readily able to find employment in the traditional fields of academic research or collection management. Thus, they were forced to move into new areas of employment, such as state government or private industry.

This development of mammalogists in the United States was paralleled by similar developments in other fields of vertebrate biology, such as ornithology or herpetology (Porter, 1972). Indeed, no one field was independent of the others and it was not uncommon for a scientist to publish papers in several fields of research. Examples would include work on non-mammalian taxa by such renowned mammalogists as Merriam (1877), Grinnell (Grinnell and Miller, 1944), Blair (1960), and many others. The new mammalogists frequently trained graduate students who worked on other taxonomic groups, and other vertebrate zoologists did the same. A definite snowball effect occurred in the development of vertebrate zoologists. By the 1970's, each state had

mammalogists employed by the state and federal government, by industry, and as independent consultants. Mammalogists were employed at all levels of education, from elementary schools through universities.

Consider how explosive this disciplinary evolution was, with comparable patterns occurring in all taxonomic fields. Taxonomically-oriented biologists were soon outnumbered by scientists with interest in physiological and ecological mammalogy. The flowering of vertebrate research was underway. It had all begun with the early survey research, and it took less than a century to produce a rapidly expanding informational base on mammalian biology and other disciplines.

Unfortunately, it is not possible to isolate one discipline, or even several disciplines, and still be able to perceive the changes in environmental awareness that were occurring in the society of the United States. As people became more interested in wildlife, and as sport hunters demanded access to wildlife for hunting, laws were passed that protected game and non-game wildlife species as a state and national resource (Tober, 1981). State and national parks were established, and protection of wildlife was entrusted to both state and national law enforcement officers.

Within U. S. society, more and more people were receiving some sort of formal training in one or another aspect of natural history, whether in grade school or high school. Beyond this formal education, however, was a great deal of informal education about nature. Beginning in the 1960's and continuing to the present day, U. S. citizens receive an almost constant flow of information on some aspect of environmental biology. Newspapers carry stories about animals or plants, pollution or ecology. Additional information is available in magazines, books, comics, and on television and movies.

The interrelatedness of informal education systems is particularly noticeable in the United States. The citizens have been conditioned over time to possess a favourable attitude toward their natural environment. This attitude is manifested in laws being passed that protect species and habitats. Biologists are generally well respected by the society, whether they be wildlife technicians or research scientists ; the importance of their work is appreciated by most segments of the population. While the overall levels of public awareness and concern may not be as high as professional biologists or officers in national wildlife societies might wish, they nevertheless operate within a society that in 1981 contributed 13.7 billion dollars to some aspect of wildlife biology (Lane, 1983). Membership in environmental organisations in 1981 was more than 16 million people and, in the 1980 presidential elections, one of the candidates for president was Dr. Barry Commoner, a well-known



environmental scientist, whose political platform was primarily based on matters pertaining to environmental awareness, including nuclear arms control.

#### ENVIRONMENTAL AWARENESS IN ARGENTINA

In many ways, Argentina recalls the United States of an earlier era. The country is large and supports a low population having a high literacy rate. There is a well-developed middle class and, despite recent economic problems, Argentine society is well-industrialised, modern and dynamic. Like the United States of the late 1800's, however, Argentines have yet to develop a widespread conservation ethic, and the level of environmental awareness of the citizenry is low. Nature is still viewed as an entity that needs to be subdued in order to provide some measurable monetary profit to society (Ojeda and Mares, 1982). By examining the history of mammalogy in the country, we can obtain some idea of why the present-day situation has developed.

Unlike the United States, Argentina never had a coordinated national faunal survey. No giant in mammalogy who possessed the requisite political connections (as did C. Hart Merriam, with his friendship of President Theodore Roosevelt) ever appeared on the scientific/political scene. Several of the renowned naturalists who worked in Argentina were foreigners and published their work elsewhere. Examples are Felix de Azara, who worked in the late 1700's and early 1800's and published in Spain, Alcides d'Orbigny (worked in the early 1800's and published in France, where his collection was sent), F. Lahille (early 1900's, works published in France), and J. A. Allen (worked in early 1900's, published in the United States) (Crespo, 1961). In the early 1900's, large collections of mammals were made for people employed by the great British mammalogist, Oldfield Thomas, who published numerous systematic studies of Argentine mammals.

In 1925, a towering figure in mammalogy, the Spaniard, Angel Cabrera, began living and working in Argentina. In his scientific career he would publish 218 scientific articles on mammals, 27 books and more than 400 popular articles (Crespo, 1960). Cabrera and his frequent collaborator, Jose Yepes, collected throughout Argentina, but never in the exhaustive manner characteristic of Merriam and his associates. Later mammalogists, such as A. C. Llanos, Jorge Crespo, and de la Barrera also collected in various parts of the country, but the collections they amassed were not extensive by North American standards. Their published works, however, provide much of the foundational material on the natural history of Argentina's mammals. Nevertheless, as recently as 1980, the five largest collections of mammals in Argentina

contained a total of only 32,260 specimens of mammals (Genoways and Schlitter, 1981). This can be compared with the United States, where in 1973 it was reported that 10 individual collections of mammals each contained more than 32,000, with the sum total of all U. S. mammal collections being approximately 2,200,000 specimens (Choate and Genoways, 1975).

Clearly, the basic survey work required to initiate the process of mammalogical informational research/education has not been carried out in Argentina, despite the heroic personal efforts of several mammalogists. Because of this, there has not been a rapidly increasing technical research base in the country. Thus, the foundational literature that is the key to the semi-technical publications on nature is to this day unavailable within the country. Many early collections of mammals had been preserved in museums outside the country, but even these collections were not too extensive, nor had they been made by Argentine scientists. The sporadic collecting activities of the 19th and 20th centuries were no substitute for broad based systematic surveys that had been well studied and had the results published within a reasonable time. The first important link in the causal chain has thus never been forged.

Lacking basic research papers and survey publications, it was not until 1981 (Olrog and Lucero, 1981) that a field guide to the mammals of Argentina was published. The book is primitive by modern standards, but was a "first" and its very small printing was exhausted in less than two years. No widely available field guide to any vertebrate group in Argentina has yet been published. The semi-technical bridge between the scientist and the educated public has not yet been built, nor are the materials with which to build it at hand.

With semi-technical publications scarce, out of print, or unavailable entirely, it is no surprise that literature dealing with mammals in a non-technical popular fashion has not been published. Those authors with the interest or ability to write about nature in a popular fashion would have to consult the primary literature in Argentina, the United States, England, France and Germany in order to construct a story on an Argentine mammal.

As noted above, education is a process of great complexity. Primary literature in Argentina is scarce, semi-technical literature even more uncommon, and popular literature on nature hardly available at all. Thus, most people in Argentina do not perceive the need to learn about nature, their curiosity has never been piqued. Environmental education at the elementary and high school levels is practically nonexistent. There is a general unawareness in society about Argentina's fauna and flora

and little concern for the pronounced habitat modification that is affecting the entire country (Ojeda and Mares, 1982). While laws are passed to protect wildlife, there is no enforcement of these laws and little understanding on the part of the public as to why laws that are ecologically based should be supported.

Even though Argentina has had a number of very fine mammalogists, the pattern of research collection in the United States where professors of mammalogy and their students amassed extensive collections (e. g. Berkeley, University of Kansas, University of Michigan, Harvard University, University of New Mexico) has not developed. Thus, training programmes in mammalogy and other disciplines never developed in Argentina, whereas collections of mammals in the United States are growing by about 120,000 specimens per year, or four times the number of mammals that have been amassed in Argentine collections in over 100 years. The pervasive influence of trained mammalogists, ornithologists and other field biologists on their society has not been felt in Argentina. The intricate web of interrelationships that characterises the development of an ecological ethic has never been constructed (Mares and Ojeda, 1984 ; Ojeda and Mares, 1984).

The differences between the pattern of development of a social awareness of nature in Argentina and the United States are profound. It must be remembered, moreover, that Argentina is much more advanced in its basic data base and in its environmental awareness than are most countries in the world. The critical mass of young biologists interested in mammals that is required to begin an irreversible trend in scientific development is even now forming. This cannot be said for many countries on earth.

#### THE ROLE OF MAMMAL COLLECTIONS AND CURATORS

Curators of mammal collections are the initial force in the model described in Figure 2. Their minimal duties involve assisting in aspects of passive education (Fig. 1) : serving as advisors on exhibits, developing collections, and acting as resident experts on questions dealing with mammals. However, minimal efforts are no longer acceptable for curators. The complexities of the modern world and the needs of modern society are such that fulfilling one's professional duties at a minimal level does little to advance the cause of science. Technological pressures on habitats and burgeoning human populations are rapidly altering the world's ecosystems. We are faced with massive extinctions in the coming decades if we do not stay the current rate of species loss (Council on Environmental Quality, 1982). Because of the causal chain illustrated in Figure 2, it is clear that museum curators have a responsibility to

provide the foundational data necessary to aid the transition from an unaware public to one that is actively concerned with nature. Collecting mammals and curating the collection is not sufficient activity from professionals who should be playing a key role in public education. I suggest, however, that even the production of scholarly works should be viewed as insufficient activity on the part of curators.

Who is in a better position than a curator of mammals to produce the semi-technical field guides that are necessary in each society ? The curator knows the fauna of his region more profoundly than do other scientists. Who, more than the curator, has a greater personal involvement in the development of an environmental awareness in his society ? And who more than the curator has ready access to the primary materials required to produce semi-technical publications ? The answers to these questions are obvious. If we are to have the all-important informational bridge between the scientist and the lay public, it is incumbent upon us, the curators, to develop these works.

The work of C. Hart Merriam and his immediate associates, as well as the work of the curators of research collections in the United States, was a critical stimulus to the development of natural history research and to the societal conservation ethic that is in operation today. Merriam, Allen, Grinnell, Hall, Burt, Hooper and others not only helped develop a science, but had a significant if immeasurable impact on their society. Their actions helped shape our current views of nature. Their work shows us that, although widespread public education is an extremely slow process, it can occur over a single lifetime. At present, the level of environmental awareness throughout most of the world is low. Yet we realise that without an environmental ethic, without public policies that are closely attuned to environmental needs, the quality of life in the world of the near future will be decidedly poorer. Indeed, many of the species we so desperately need to study will no longer be in existence. Museums, through passive education programmes and particularly through active programmes can be one of the primary agents of public education. Their curators are a vital link in the system and their actions can make the difference.

#### SUMMARY

A survey of the availability of popular literature on mammals was conducted by means of a questionnaire that was mailed to mammal curators and museum workers throughout the world. Responses show that there is a wide disparity in the types of literature that are available

within a country for the use by non-technical readers. Scientific accounts of the mammals of any particular country or region are usually published in English or German, and are widely utilised by museum specialists in all countries, although the availability of even these specialised works may be quite limited. Nevertheless, there is a general awareness by mammalogists of the technical literature concerning the mammals of their country, even though this literature may be outdated or no longer in print. The situation obtaining with the scientific literature, however, is in marked contrast to that found for the popular or semipopular literature on mammals that is produced for a general nonspecialist audience. Few countries of the world have a literature that brings non-technical information on mammals to the general public. In this report, I compare the types of mammal literature available in the United States, an exceptionally rich area for all types of mammal literature, with those available in Argentina, a country having an exceedingly impoverished mammal literature.

I examine the history of the development of these two patterns of literature availability and discuss the importance of popular and technical literature to the evolution of a conservation ethic. It is clear that a general conservation awareness by citizens at all levels of society is important if a country is to develop an effective programme of environmental protection. The widespread availability of popular literature on nature, such as mammal field guides written in the native language of the country, is an important component of conservation education. The publication of such guides and associated literature seems to be a synergistic process—as a guidebook on one particular taxonomic group appears, others follow. As these books proliferate, there is a general upgrading of the public's awareness of nature, including those non-specialists who are in decision-making roles in government, industry and education.

The United States developed its elevated level of conservation awareness over almost a century, a time period which saw a rapid diminution of biotic resources because of widespread habitat modification and largely uncontrolled hunting practices. An important factor in the development of conservation ideas in the United States was the availability of a data base on the distribution of biotic resources. This data, acquired through intensive faunal and floral surveys, offered a strong foundation for the ecological and management research that characterised the Twentieth Century. It would have been difficult indeed to have initiated ecological studies on species whose fundamental taxonomic status had not been worked out before-hand. All ecological research assumes that the organisms examined are correctly identified and have their phylogenetic affinities at least initially worked out. Thus ecological research and, by extension, conservation biology, have systematic and survey research as their foundational literature.

In Argentina, basic systematic and biogeographic research is incomplete. Although the level of information on mammals and other taxa has improved greatly in recent years, there is still no complete survey of the country's mammals that has been published. Because of this, field guides and other widely disseminated popular materials have not become generally available. The complex interrelationship of literature availability and a formal interest by students and educators in the subject of environmental awareness that occurred in the United States has not taken place in Argentina. General environmental interest among the public is low, and an effective conservation ethic is yet to develop. While the lack of such an ethic cannot be directly related to the paucity of foundational literature in the country, it seems to offer compelling evidence that a natural historical informational base is a *sine qua non* of environmental awareness.

## REFERENCES

- BLAIR, W. F. 1960. *The Rusty Lizard*. Univ. Texas Press, Austin.
- CARSON, R. 1962. *Silent Spring*. Houghton Mifflin, New York.
- CHOATE, J. R. and GENOWAYS, H. H. 1975. Collections of recent mammals in North America. *J. Mammal.*, **56** : 452-502.
- Council on Environmental Quality. 1982. *The Global 2000 Report to the President*. Penguin Books, New York.
- CRESPO, J. A. 1960. Angel Cabrera (1879-1960). *J. Mammal.*, **41** : 540.
- CRESPO, J. A. 1961. Panorama Zoologico Argentino mamiferos. *Physis*, **22** : 241-247.
- EHRlich, P. R. 1968. *The Population Bomb*. Ballantine Books, New York.
- GRAHAM, F. G., Jr. 1980. Roger Peterson builds a blockbuster. *Audubon Mag.*, September, 1980 : 58-63.
- GENOWAYS, H. H. and SCHLITTER, D. A. 1981. Collections of Recent mammals of the world, exclusive of Canada and the United States. *Ann. Carnegie Mus.*, **50** : 47-80.
- GRINNELL, J. and MILLER, A. H. 1944. The distribution of the birds of California. *Pacif. Cst. Avifauna*, **27** : 1-608.

- LANE, H. U. 1983. *The World Almanac and Book of Facts 1983*. Newspaper Enterprise Assoc., Inc., New York.
- MARES, M. A. 1982. The scope of South American mammalian biology : perspectives on a decade of research. *In : Mammalian Biology in South America* : 1-26. M. A. Mares and H. H. Genoways (eds.). Pymatuning Lab. Ecol. Spec. Publs. No. 6, Linesville, Pennsylvania.
- MARES, M. A. 1985. Mammal and museum literature : an international survey. *Acta zool. Fennica*, **170** : 57-60.
- MARES, M. A. and BRAUM, J. K. 1986. An international survey of the popular and technical literature of mammalogy. *Ann. Carnegie Mus.*, **55** : 149-209.
- MARES, M. A. and OJEDA, R. A. 1984. Faunal commercialization and conservation in South America. *Bioscience*, **34** : 580-584.
- MERRIAM, C. H. 1877. A review of the birds of Connecticut, with remarks on their habits. *Trans. Conn. Acad. Arts Sci.*, **4** : 1-150.
- OJEDA, R. A. and MARES, M. A. 1982. Conservation of South American mammals : Argentina as a paradigm. *In : Mammalian Biology in South America* : 505-521. M. A. Mares and H. H. Genoways (eds.). Pymatuning Lab. Ecol. Spec. Publs. No. 6, Linesville, Pennsylvania.
- OJEDA, R. A. and MARES, M. A. 1984. La degradacion de los recursos naturales y la fauna silvestre en la Argentina. *Interciencia*, **9** : 21-26.
- OLROG, C. C. and LUCERO, M. M. 1981. *Los mamiferos de Argentina*. Fundacion Miguel Lillo, Tucuman, Argentina.
- OSGOOD, W. H. 1943. Clinton Hart Merriam—1855-1942. *J. Mammal.*, **24** : 421-436.
- PETERSON, R. T. 1934. *A field guide to the birds* : xxi+167. Houghton Mifflin Company, New York.
- PORTER, K. R. 1972. *Herpetology*. W. B. Saunders, Philadelphia.
- TOBER, J. A. 1981. *Who owns the Wildlife ?* Greenwood Press, Westport Connecticut.

## DISCUSSION

- Q. *The popular publications which are produced—how are they distributed and how are they sold ? Do they bring any profit to the publisher ? Are they subsidised ?*
- A. Some field guides are subsidised. Many bring a profit to the publisher—often a significant profit. Publishers have their own distribution system, although mail-order lists are frequently used.
- Q. *After outlining the evolution of public awareness in natural history and thus support to the scientists. What is your advice to those of us who are interested and yet have no support in our own countries ? Should we sit around and wait for our national public to evolve awareness of nature ?*
- A. I believe that we are responsible for assisting the public to develop an awareness of nature. We do this *via* our public education activities, including publishing semi-technical and popular literature. Thus waiting is not the answer. We have waited long enough.
- Q. *Although much progress has been made in environmental education in the U. S., is there still not a large segment of the general public particularly in urban areas that lacks knowledge about wildlife and ecology ?*
- A. Yes—the general public often seems to know less about wildlife than we, the professional biologists might desire. But their awareness of the environment is actually quite high when viewed on a global scale. Nevertheless, much work remains to be done on the population of the U. S. to elevate their awareness of nature.
- Q. *For the survey of the availability of popular literature you mailed questionnaires throughout the world. I would like to know if any such questionnaires was sent to India ? In fact, inspite of economic pressure, ZSI, BNHS, CAZRI, Dept. of Environment and many other organisations used to publish popular articles and monographs on natural history in English and regional languages. ZSI publishes a regular journal 'Zoologiana' with popular articles.*
- A. Several questionnaires were sent to various Indian Collections, although I do not have the actual data at hand. All collections listed in the Genoways & Schlitter survey of the World's mammal collections were queried.





## **ADVANCES IN SYSTEMATIC MAMMALOLOGY**

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### **INTRODUCTION**

It seems to me that it is not only an impossible task but a bit presumptive to think that a short paper such as this can do justice to the subject of advances in systematic mammalogy. Additionally, if they are truly significant "advances" it is unlikely that any one person is capable of properly presenting a balanced presentation and perspective overview. Therefore the reader should understand that the opinions below are biased from a single person's viewpoint and the literature cited is not intended to be comprehensive. With these protective caveats I make the following observations.

The changes in systematic mammalogy have been on many fronts ranging from the changes (and in some cases advances) in the philosophy of systematics, to high tech methodologies. I shall try to touch on the full spectrum.

### **PHILOSOPHY AND APPROACH TO DETERMINING RELATIONS**

I think that most systematic mammalogists agree that a systematic classification should reflect evolutionary history and common ancestry. However, even if we knew the true family tree of all mammals, I think that there would be disagreement among mammalogists on how to convert such a tree into the categories: genera, families, orders, and so forth. Not only do we not know the true family tree, we also have the problem that many currently recognised genera, families, orders, and other categories have a history of being defined from a Gestalt, often with little agreement as to their limits. Systematics has often been as much art as science and higher taxonomic categories have simply been what taxonomists have called them. Therefore, it should not be surprising that in systematics there have been repeated efforts to make classification methodologies more scientific.

The two most recent attempts have been numerical taxonomy or phenetics (Sneath and Sokal, 1973; Rohlf and Sokal, 1981) and cladistics (Hennig, 1966; Farris, 1979; Funk and Brooks, 1981; Platnick

and Funk, 1983). Thank goodness, it is far beyond the scope of this paper to deal with the details of these two camps of thought, but the reader is referred to the numerous, often heated, discussions published during the last ten years in the journal, *Systematic Zoology*. Basically phenetics and numerical taxonomy would classify taxa based on how similar they are without regard to whether the similarities are primitive or derived. Alternatively cladistics associates taxa only if they share derived character states. Additionally, cladistics embraces the ideas of parsimony and outgroups (Wiley, 1981; Watrous and Wheeler, 1981; Farris, 1982; Maddison *et al.*, 1984; Smith and Hood, 1984).

Several points appear to me to be worthy of note. First, a significant number of the persons who favour either cladistics or phenetics often border on a religious commitment to these ideas. In my opinion, there is no place in science for such a fanatic attitude and I do not think that systematics is better off as a result of these over zealous people. It is ironic that such a religious fervor is associated with an attempt to be more scientific. Second, as far as mammals are concerned, very few papers have successfully employed these techniques to a point where a superior classification has resulted. To some extent this is because there is a large gap between theory and application. The bottom line is, however, that the theories of numerical taxonomy and cladistics have had little impact on development of the currently accepted mammalian classification (Anderson and Jones, 1984). Third, one extremely valuable aspect of cladistical analysis is that it provides a measure of convergences and/or reversals. For example for chromosomal rearrangements identifiable with G-bands, convergent evolution seems to be a significant problem (Robbins and Baker, 1981; Rogers, 1983; Hood *et al.*, 1984). However, not until anatomical, electrophoretic, DNA as well as other types of data sets are analysed under similar methods will it be apparent if convergence is less a problem for these data sets. Fourth, I would also like to note that although earlier taxonomists may not have understood our "more modern" techniques, I have been impressed with how accurate some of these early works have proven when tested with more recently developed methods. Examples are Osgood's (1909) revision of *Peromyscus* and Miller's (1907) revision of the families and genera of bats.

On a more specific level, for G-band chromosomal data generated in my laboratory we have attempted to use the cladistical methods (Patton and Baker, 1978; Baker and Bass, 1979; Baker *et al.*, 1983; Haiduk and Baker, 1982, 1984; Stangl and Baker, 1984). Hood and Smith (1982) also used a cladistic analysis of the histology and anatomy of the female reproductive tracts of bats. An example of biochemical data being cladistically analysed is Goodman *et al.* (1982a), who produced a hypothesised phylogenetic tree for the mammalian orders and fairly

detailed study of many primates. In all of these studies, there is generally a good agreement with existing classifications and in several examples where previous classifications have been poorly defined the new study also was indecisive.

#### COMPUTERS AND NUMBER CRUNCHING

As data sets become more complex and varied it is only natural that computers and associated statistical programmes would be critical to systematic analysis, regardless of the philosophy that is favoured. Just as each data set (morphological, chromosomal, genic, and others) has its own strengths and limitations, so does each statistical programme and a most critical aspect of successful utilisation is the proper choice of the programme for a specific question involving a specific data set. From my perspective, one needs a computer just to keep up with the available programmes and my understanding of what these programmes can do is primarily faith in the word of statisticians and computer types. Nonetheless here is my limited overview.

Basically there are two broad categories of systematic methods for dealing with multivariate data sets—clustering and statistical. Typically (although not necessarily) the statistical techniques are considered to be part of phenetic methodology, and involve some type of analysis of overall similarities. Clustering methods may be phenetic (based on overall similarities) or cladistic (based on shared derived similarities). Neff and Marcus (1980) provided an overview of systematic philosophies, algorithms, and available computer programmes.

During the past decade or so a number of computer programmes and programme packages have been developed and distributed in order to ease analysis of data and to proliferate the systematic philosophies of the programmes' authors. Three widely used cladistic packages available are PAUP (David L. Swofford), PHYSYS (James S. Farris), and Joe Felsenstein's package. Each of these does Wagner-type clustering under a number of user-defined constraints, and various of them will also do other types of analyses (For example, character compatibility, user-defined tree analysis).

Notwithstanding the availability of these and other programmes for some years, few cladistic studies of mammals have utilised them. Carleton (1980), in his study of cricetine rodents, utilised and compared results from Prim networks, Weighted Invariant Step Strategy (WISS) trees, and Wagner trees based on morphologic data.

Phenetic clustering methods have been more commonly used in mammalian systematic studies, perhaps due in part to the widespread

availability of the NTSYS package developed by Rohlf, Kishpaugh, and Kirk. This package provides a number of clustering programmes as well as principal components analysis and minimum spanning network. Authors who have used various of these techniques in systematic studies include Findley (1972), Genoways (1973), Best (1978), and Carleton (1980). Other statistical methods used less typically or for more specific application include discriminant analysis (Smith and Starrett, 1979), and analysis of variance (Owen and Webster, 1983).

A ubiquitous concern in systematic analysis of mammal data sets is that of size. Lemen and Freeman (1984), in an analysis of bat data, provide a discussion of the taxonomic meaning carried by the size and shape components of a morphometric data set. The usual approach to the "problem" of size has been an attempt to remove the effect of size by the use either of ratios or removal of the first principal component (for example, Best, 1978; Douglas, *et al.*, 1984). However, use of either of these techniques assumes linearity of size relationships among taxa (Pimentel, 1979), and Atchley (1978) has raised other objections to the use of ratios. Wood (1983) suggested that the systematist's real objective should not be to remove the effect of size, but rather that portion of the data set variance, which he called the "common part" ; he further outlined a regression procedure to accomplish this.

One of the potential problems of the incorporation of complex computer-aided data analyses is that the researcher may depend too heavily on *a posteriori* reasoning. Often, the hypotheses tested are generated after the data analysis has been performed. The danger in such processes is that the investigations become data oriented and the study is not conceived as an integral part of the scientific method. In order for the field of systematic biology to advance significantly as a recognised science greater emphasis must be placed on experimental design and adherence to scientific principles.

#### NEWER TYPES OF DATA FOR SYSTEMATICS

An old cliché in systematics is that "systematists aren't proud, and they will use any data available." With the expanding horizons of biotechnology the potential data are mind boggling. Cellular structure, subcellular structure, and biochemical studies have all recently been interpreted in a systematic framework. Studies on sperm morphology (Forman and Genoways, 1979), ultrastructure and light microscopic histology of the alimentary canal (Phillips *et al.*, 1984), surface structure of arvicoline rodent teeth (Koenigswald, 1980), and hair structure in heteromyids (Homan and Genoways, 1978) serve as examples of the types of morphological data used in a systematic context.

*Electrophoresis*

Protein electrophoresis is by far the most commonly used technique for determining the genetic relatedness of taxa. As a result of electrophoretic studies there have been assessments and reviews of genetic variation in natural populations (Nevo, 1978) and the reader is referred to Smith *et al.* (1982). Prior to electrophoretic studies of natural populations, it was generally accepted that species of animals contained little genetic variability. Smithes (1955) and Lewontin and Hubby (1966) demonstrated that organismal populations did indeed contain high levels of genetic variability. Additionally, electrophoretic studies of this variability have clearly documented that the populational structures over short geographic distances are much more complex than previously thought (Selander, 1970; Chesser, 1983, Ryman *et al.*, 1980).

Because of the amount of variability found in natural populations, the systematic value of electrophoretic studies in mammals has generally been most valuable to the lower taxonomic levels (species and closely related genera) rather than in relations of higher levels (such as orders and families).

The primary problems associated with electrophoresis are that it is difficult to be sure that the identical migration of a band on a gel indicates genetic identity, as well as and the inability to make comparisons between distantly related taxa. Nonetheless because electrophoresis is relatively inexpensive and easily performed from a technical standpoint, it will continue to be a widely utilised technique.

*Immunology*

One of the oldest biochemical techniques used to study systematic relationships of mammals has been immunology. Probably the most significant results of the immunological studies is the development of the molecular clock hypothesis (Sarich, 1969; Wilson *et al.*, 1977; Sarich and Cronin, 1980), which has resulted from micro-complement fixation studies (Sarich and Wilson, 1966). Because immunological studies have considerable resolving power for both closely and distantly related taxa and because the techniques are relatively well understood, I suspect that the technique will continue to be used in mammalian systematics (Arnold *et al.*, 1982 Baker *et al.*, 1981 Fuller *et al.*, 1984). Nonetheless, the immunological techniques have the problems of 1) only estimating how different the proteins are from different taxa (Sarich and Wilson, 1966) (2) examples of well documented non-clock like evolution (Arnold *et al.*, 1982) and, (3) a reduced resolving power because of variation of reciprocity studies (Sarich and Cronin, 1980).

### *Sequencing of Amino Acids of Proteins*

One of the types of data that has been most successfully converted into systematic hypothesis is that generated from amino acid sequences analyses from polypeptide chains (Goodman, *et al.*, 1982a, 1982b, 1982c). Data from such studies have the advantage of being discrete, readily analysed by cladistical methods, and sufficiently conservative in rate of evolution that comparisons between higher taxa (such as orders and classes) can be made. Because there are literally thousands of available proteins, the theoretical limit for such studies is boundless (Goodman, 1982). However, because these studies are relatively expensive and technically complicated, it is likely that such studies will be performed in a limited number of laboratories and on a relatively small number of proteins and taxa.

### *DNA Analysis*

As DNA is the genetic material, there is considerable anticipation in the development of the various techniques required to produce the type of data needed for systematic work. Although this is a relatively new field some of the first studies have been most promising (for instance see the DNA/DNA hybridisation studies of Brownell, 1983 and Sibley and Ahlquist, 1984; the restriction endonuclease maps of Templeton, 1983; the mitochondrial DNA studies on primates by Brown *et al.*, 1982, *Peromyscus* by Avise *et al.*, 1979 and Lansman *et al.*, 1983, and *Geomys* by Avise *et al.*, 1979; DNA spacer sequences studies of Appels and Honeycutt, in press; and studies on the genomes of closely related species, Dover *et al.*, 1980). There are several problems associated with DNA studies (Dover, 1980), however, it appears to me that the number of laboratories, and number of productive scientists, and the magnitude of medical and scientific funding of DNA biochemistry will result in an immediate significant volume of literature, some of which will be systematic in nature. Certainly this is the hottest area of systematic research.

### *Chromosomal Studies*

Ever since chromosomal data have been available, they have been interpreted as having systematic value. Newer techniques for mammalian chromosomes produce differential staining which is thought to document genetic homology (Haiduk and Baker, 1984). At this time, it is probably safe to conclude that non-differentially stained chromosomes and C-bands (regions of highly repetitive DNA sequences) will have very limited systematic value (Baker *et al.*, 1983). Of the various types of differential staining techniques, G-bands appear to be the most useful to systematics. With the advent of bone marrow

methods (Lee and Elder, 1980), field techniques (Baker *et al.*, 1982), and high resolution banding (Yunis *et al.*, 1980; Yunis and Prakash, 1982) the potential uses are great. The primary problems associated with determining G-band homology are that in some closely related taxa the G-band sequences can be radically rearranged (Baker and Bickham, 1984), genetic homology is assumed but not proven, and convergent evolution has been found in a number of cases. Chromosomal G-bands have been used to provide systematic hypotheses in a number of papers (Yunis *et al.*, 1980; Baverstock *et al.*, 1983; Baker and Bass, 1979; Baker *et al.*, 1983). Additionally, chromosomal data have some value in defining cryptic species (Baker, 1984; Capanna, 1982).

#### ROLE OF MUSEUMS

One final note about the role of museums in systematic studies involving the more recent advances in biotechnology. The need for voucher specimens deposited in reputable museums is imperative. Museum personnel can play a most valuable and critical role in being sure that proper data are obtained, in order that specimens used in the newer types of studies are clearly referenced as a tissue source for specific systematic studies. Problems associated with such systematic studies and vital tissue collections are addressed in Dessauer and Hafner (1984) and Baker and Haiduk (1985). It is my opinion that we are at a most exciting time for discoveries in the area of mammalian evolution and systematics and the museums of the world are a most critical component to the proper scientific procedures associated with such discoveries.

#### SUMMARY

As new scientific methods have been developed that provide more detailed information on molecular and cellular biology of mammals, it is only logical that such methods be used to generate data for systematic studies. For maximum value such studies must not only maintain a state of the science for these modern techniques but they also must conform to modern museum standards. Proper voucher specimens must be prepared in a way to document which tissues and types of data were taken and what studies were made. If a museum contains specimens with such data, it significantly increases the value of that collection.

Methods that are commonly used include : differentially stained chromosomes, electrophoretic definition of proteins, immunological studies on proteins, amino acid sequences for a specific protein, DNA hybridization, and mitochondrial DNA studies by restriction endonuclease. How to evaluate the results of such studies and problems in



establishing a credible data set are discussed. All techniques that have been extensively studied, show areas where that technique can provide definition in some parts of the classification of mammals. However, all techniques that have been extensively studied also show areas in which they provide little or no resolution. Clearly, knowing the strengths and weaknesses for any given method is critical to designing proper systematic research programmes. Within most mammalian taxonomic groups, systematic schemes are in need of critical test and the future belongs to a balanced study from a variety of systematical techniques including data from the classical, skin, skull, and other anatomical methods as well as those from more sophisticated molecular techniques that are now becoming available.

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#### REFERENCES

- ANDERSON, S. and JONES, J. K. Jr. 1984. *Order and families of Recent mammals of the world*. John Wiley and Sons, New York, 686 pp.
- APPELS, R. and HONEYCUTT, R. L. In Press. DNA space sequences : Phylogenetic relationships. In : *DNA systematics : Evolution*. S. K. Dutta, (ed). CRC Press, Boca Raton, Florida.
- ARNOLD, M. L., HONEYCUTT, R. L., BAKER, R. J., SARICH, V. M. and JONES, J. K. Jr. 1982. Resolving a phylogeny with multiple data sets : a systematic study of phyllostomid bats. *Occ. Pap., Mus. Texas Tech Univ.*, 77 : 1-15.
- ATCHLEY, W. R. 1978. Ratios, regression intercepts, and the scaling of data. *Syst. Zool.*, 27 : 78-83.
- AVISE, J. C., GIBLIN-DAVIDSON, C., LAERM, J., PATTON, J. C. and LARSMAN, R. A. 1979a. Mitochondrial DNA clines and matriarchal phylogeny within and among geographic populations of the pocket gopher, *Geomys pinetis*. *Proc. natn. Acad. Sci.*, 76 : 6694-6698.

- AVISE, J. C., LANSMAN, R. A. and SHADE, R. O. 1979b. The use of restriction endonucleases to measure mitochondrial DNA sequence relatedness in natural populations. I. Population structure and evolution in the genus *Peromyscus*. *Genet.*, **92** : 279-295.
- BAKER, R. J. 1984. A sympatric cryptic species of mammal: a new species of *Rhogeessa* (Chiroptera: Vespertilionidae). *Syst. Zool.*, **33** : 178-183.
- BAKER, R. J. and BASS, R. A. 1979. Evolutionary relationships of the Brachyphyllinae to the glossophaginae genera *Glossophaga* and *Monophyllus*. *J. Mammal.*, **60** : 364-372.
- BAKER, R. J. and BICKHAM, J. W. 1984. Karyotypic megaevolution by any other name : a response to Marks. *Syst. Zool.*, **33** : 339-341.
- BAKER, R. J. and HAIDUK, M. W. 1985. Collections of cell lines suspended by freezing. *Acta Zool. Fennica*, **170** : 90-92.
- BAKER, R. J., HONEYCUTT, R. L., ARNOLD, M. L., SARICH, V. M. and GENOWAYS, H. H. 1981. Electrophoretic and immunological studies on the relationship of the Brachyphyllinae and the Glossophaginae. *J. Mammal.*, **60** : 665-672.
- BAKER, R. J., HAIDUK, M. W., ROBBINS, L. W., CADENA, A. and KOOP, B. F. 1982. Chromosomal studies of South American bats and their systematic implications. In: *Mammalian biology in South America*: 303-327, M. A. Mares and H. H. Genoways (eds.). *Spec. Publs. Ser. Pymatuning Lab. Ecol.*, Vol. VI. Linesville, Pennsylvania.
- BAKER, R. J., KOOP, B. F. and HAIDUK, M. W. 1983. Resolving systematic relationships with G-bands: a study of five genera of South American cricetine rodents. *Syst. Zool.*, **32** : 403-416.
- BAVERSTOCK, P. R., WATTS, C. H. S., GELDER, M. and JOHNKE, A. 1983. G-Banding homologies of some Australian rodents. *Genetica*, **60** : 105-117.
- BEST, T. L. 1978. Variation in kangaroo rats (genus *Dipodomys*) of the *heermanni* group in Baja California, Mexico. *J. Mammal.*, **59** : 160-175.
- BROWN, W. M., PRAGER, E. M., WANG, A. and WILSON, A. C. 1982. Mitochondrial DNA sequences of Primates: tempo and mode of evolution. *J. Mol. Evol.*, **18** : 225-239.

- BROWNELL, E. 1983. DNA/DNA hybridization studies of muroid rodents : symmetry and rates of molecular evolution. *Evolution*, **37** : 1034-1051.
- CAPANNA, E. 1982. Robertsonian numerical variation in animal speciation: *Mus musculus*, an emblematic model: 155-177. In: *Mechanisms of speciation*. C. Bariccozzi (ed.). Alan R. Liss, Inc., New York.
- CARLETON, M. D. 1980. Phylogenetic relationships in neotomine-peromyscine rodents (Muroidea) and a reappraisal of the dichotomy within New World Cricetinae. *Misc. Publs. Mus. Zool., Univ. Michigan*, **157** : 1-46.
- CHESSER, R. K. 1983. Genetic variability within and among populations of the black-tailed prairie dog. *Evolution*, **37** : 320-331.
- DESSAUER, H. C. and HAFNER, M. S. 1984. *Collections of frozen tissues. Value, management, field and laboratory procedures, and directory of existing collections*. American Association of Systematic Collection, Lawrence, Kansas, 74 pp.
- DOUGLAS, M. E., SCHNELL, Gary D. and HOUGH, D. J. 1984. Differentiation between inshore and offshore spotted dolphins in the eastern tropical Pacific Ocean. *J. Mammal.*, **65** : 375-387.
- DOVER, G., STRACHAN, T and BROWN, S. 1980. The evolution of genomes of closely related species. *Proc. Second Intn. Cong. Syst. & Evol. Biol.*, Vancouver.
- DOVER, G. 1980. Problems in the use of DNA for the study of species relationships and the evolutionary significance of genomic differences. In: *Chemosystematics: Principles and practice*. F. A. Bisby, J. G. Vaughan, and C. A. Wright (eds.), Syst. Ass. Ser. Academic Press. New York.
- DOVER, G. 1980. Molecular drive: a cohesive mode of species evolution. *Nature*, **299** : 111-117.
- FARRIS, J. S. 1979. The information content of the phylogenetic system. *Syst. Zool.*, **28** : 483-519.
- FARRIS, J. S. 1982. Outgroups and parsimony. *Syst. Zool.*, **31** : 328-334.
- FINDLEY, J. S. 1972. Phenetic relationships among bats of the genus *Myotis*. *Syst. Zool.*, **21** : 31-52.

- FORMAN, G. L. and GENOWAYS, H. H. 1979. Sperm morphology. In: *Biology of bats of the New World family Phyllostomatidae*. Part III: 177-204. R. J. Baker, J. K. Jones, Jr. and D. C. Carter (eds.), *Spec. Publs. Mus. Texas Tech Univ.*, **16** : 1-441.
- FULLER, B., LEE, M. R. and MAXSON, L. R. 1984. Albumin evolution in *Peromyscus* and *Sigmodon*. *J. Mammal.*, **65** : 466-473.
- FUNK, F. A. and BROOKS, D. R. 1981. Advances in cladistics. *Proc. First Meeting Willi Hennig Soc.* New York Botanical Garden, Bronx, New York, 250 pp.
- GENOWAYS, H. H. 1973. Systematics and evolutionary relationships of spiny pocket mice, genus *Liomys*. *Spec. Publs. Mus. Texas Tech. Univ.*, **5** : 1-368.
- GOODMAN, M. 1982. *Macromolecular sequences in systematic and evolutionary biology*. Plenum Press, New York, 418 pp.
- GOODMAN, M., WEISS, M. L. and CZELUSNIAK, J. 1982a. Molecular evolution above the species level: branching pattern, rates, and mechanisms. *Syst. Zool.*, **31** : 376-399.
- GOODMAN, M., ROMERO-HERRERA, A. E., CZELUSNIAK, J., DENE, H. and TASHIAN, R. E. 1982b. Amino acid sequence evidence on the phylogeny of primates and other eutherians: 115-191. In: *Macromolecular sequences in systematic and evolutionary biology*. M. Goodman (ed.). Plenum Press, New York.
- GOODMAN, M., OLSON, C. B., BACKER, J. E. and CZELUSNIAK, J. 1982c. New perspective in the molecular biological analysis of mammalian phylogeny. *Acta Zool. Fennica*, **169** : 19-35.
- HAIDUK, M. W. and BAKER, R. J. 1982. Cladistical analysis of G-banded chromosomes of nectar-feeding bats (Glossophaginae: Phyllostomidae). *Syst. Zool.*, **31** : 252-265.
- HAIDUK, M. W. and BAKER, R. J. 1984. Scientific method, opinion, phylogenetic reconstruction, and nectar-feeding bats: a response to Griffiths and Warner. *Syst. Zool.*, **33** : 343-350.
- HENNIG, W. 1966. *Phylogenetic systematics*. Univ. Illinois Press, Urbana, Illinois, 263 pp.
- HOMAN, J. A. and GENOWAYS, H. H. 1978. An analysis of hair structure and its phylogenetic implications among heteromyid rodents. *J. Mammal.*, **59** : 740-760.

- HOOD, C. S. and SMITH, J. D. 1982. Cladistical analysis of female reproductive histomorphology in phyllostomatoid bats. *Syst. Zool.*, **31** : 241-251.
- HOOD, C. S., ROBBINS, L. W., BAKER, R. J. and Shellhammer, H. S. 1984. Chromosomal studies and evolutionary relationships of an endangered species, *Reithrodontomys raviventris*. *J. Mammal.*, **65** : 655-667.
- KOENIGSWALD, W. V. 1980. Schmelestruktur und morphologie in den molaren der Arvicolidae (Rodentia). *Abh. senckenb naturforsch. Ges.*, **539** : 1-129.
- LANSMAN, R. A., AVISE, J. C., AQUADRO, C. F., SHAPIRA, J. F. and DANIEL, S. W. 1983. Extensive genetic variation in mitochondrial DNAs among geographic populations of the deer mouse, *Peromyscus maniculatus*. *Evolution*, **37** : 1-16.
- LEE, M. R. and ELDER, F. F. B. 1980. Yeast stimulation of bone marrow mitosis for cytogenetic investigations. *Cytogenet. Cell Genet.*, **26** : 36-40.
- LEMEN, C. A. and FREEMAN, P. W. 1984. The genus.: a macroevolutionary problem. *Evolution*, **38** : 1219-1237.
- LEWONTIN, R. C. and HUBBY, J. L. 1966. A molecular approach to the study of genic heterozygosity in natural populations. II. Amount of variation and degree of heterozygosity in natural populations of *Drosophila pseudobscura*. *Genetics*, **54** : 595-609.
- MADDISON, W. D., DONOGHUE, M. J. and MADDISON, D. R. 1984. Out-group analysis and parsimony. *Syst. Zool.*, **33** : 83-103.
- MILLER, G. S., Jr. 1907. The families and genera of bats. *Bull. U.S. natn. Mus.*, **57** : 1-282.
- NEFF, N. A. and MARCUS, L. F. 1980. *A survey of multivariate methods for systematics*. American Museum of Natural History, New York, 243 pp.
- NEVO, E. 1978. Genetic variation in natural populations: patterns and theory. *Theor. Popul. Biol.*, **13** : 121-177.
- OSGOOD, W. F. 1909. Revision of the mice of the American genus *Peromyscus*. *N. Am. Fauna*, **28** : 1-285.

- OWEN, R. D. and WEBSTER, W. D. 1983. Morphological variation in the ipanema bat, *Pygoderma bilabiatum*, with description of a new subspecies. *J. Mammal.*, **65** : 146-149.
- PATTON, J. C. and BAKER, R. J. 1978. Chromosomal homology and evolution of phyllostomatoid bats. *Syst. Zool.*, **27** : 449-462.
- PHILLIPS, C. J., STUDHOLME, K. M. and FORMAN, G. L. 1984. Results of the Alcoa Foundation Suriname Expeditions. VIII. Comparative ultrastructure of gastric mucosae in four genera of bats (Mammalia: Chiroptera), with comments on gastric evolution. *Ann. Carnegie Mus.*, **53** : 71-117.
- PIMENTAL, R. A. 1979. *Morphometrics: multivariate analysis of biological data*. Kendall/Hunt Press, Dubuque, Iowa.
- PLATNICK, N. I. and FUNK, V. A. 1983. Advances in cladistics. *Proc. Second Meeting Willi Hennig Soc.*, Columbia Univ. Press, New York.
- ROBBINS, L. W. and BAKER, R. J. 1981. An assessment of the nature of chromosomal rearrangements in 18 species of *Peromyscus* (Rodentia : Cricetidae). *Cytogenet. Cell. Genet.*, **31** : 194-202.
- ROGERS, D. S. 1983. Phylogenetic affinities of *Peromyscus* (*Megadontomys*) *thomasi* : evidence from differentially stained chromosomes. *J. Mammal.*, **64** : 617-623.
- ROHLF, F. J. and SOKAL, R. R. 1981. Comparing numerical taxonomic studies. *Syst. Zool.*, **30** : 459-490.
- RYMAN, N., REUTERWALL, C., NYGREN, K. and NYGREN, T. 1980. Genetic variation and differentiation in Scandinavian moose (*Alces alces*) : are large mammals monomorphic ? *Evolution*, **34** : 1037-1049.
- SARICH, V. M. 1969. Pinniped origins and rate of evolution of carnivore albumins. *Syst. Zool.*, **18** : 286-295.
- SARICH, V. M. and CRONIN, C. E. 1980. South American mammal molecular systematics, evolutionary clocks, and continental drift. In: *Evolutionary biology of the New World monkeys and continental drift*: 399-421. R. L. Ciochon and B. Chiarelli (eds.). Plenum Publ. Corp., New York.

- SARICH, V. M. and WILSON, A. C. 1966. Quantitative immunochemistry and the evolution of primate albumins : micro-complement fixation. *Science*, **154** : 1563-1566.
- SIBLEY, C. G. and AHLQUIST J. E. 1984. The phylogeny of hominoid primates, as indicated by DNA/DNA hybridization, *J. Mol. Evol.*, **20** : 2-15.
- SELANDER, R. K. 1970. Behavior and genetic variation in natural populations. *Am. Zool.*, **10** : 53-66.
- SMITH, J. D. and STARRETT, A. 1979. Morphometric analysis of chiropteran wings: 229-316. In: *Biology of bats of New World family Phyllostomatidae*. Part III. R. J. Baker, J. K. Jones, Jr. and D. C. Carter. (eds.). *Spec. Publs. Mus. Texas Tech. Univ.*, **16** : 1-441
- SMITH, J. D. and HOOD, C. S. 1984. Genealogy of the New World nectar-feeding bats reexamined: a reply to Griffiths. *Syst. Zool.*, **33** : 435-460.
- SMITH, M. W., AQUADRO, C. F., Smith, M. H., CHESSER, R. K. and ETGES, W. J. 1982. *Bibliography of electrophoretic studies of biochemical variation in natural vertebrate populations*. Texas Tech Univ. Press, Lubbock, Texas, 105 pp.
- SMITHES, O. 1955. Zone electrophoresis in starch gels: groups variation in the serum proteins of normal human adults. *Biochem. J.*, **61** : 629-641.
- SNEATH, P. H. A. and SOKAL, R. R. 1973. *Numerical taxonomy*. W. H. Freeman and Co., San Francisco, 573 pp.
- STANGL, F. B., Jr and BAKER, R. J. 1984. Evolutionary relationships in *Peromyscus* : congruence in chromosomal, genic and classical data sets. *J. Mammal.*, **65** : 643-654.
- TEMPLETON, A. R. 1983. Phylogenetic inference from restriction endonuclease cleavage site maps with particular reference to the evolution of humans and the apes. *Evolution*, **37** : 221-244.
- WATROUS, L. E. and WHEELER, Q. D. 1981 The outgroup comparison method of character analysis. *Syst. Zool.*, **30** : 1-11
- WILEY, E. O. 1981 *Phylogenetics : the theory and practice of phylogenetic systematics*. John Wiley and Sons, New York.

- WILSON, A. C., CARSON, S. S. and WHITE, T. J. 1977. Biochemical evolution. *Ann. Rev. Biochem.*, **46** : 573-639.
- WOOD, D. S. 1983. Character transformations in phenetic studies using continuous morphometric variables. *Syst. Zool.*, **32** : 125-131
- YUNIS, J. J. and PRAKASH, O. 1982. The origin of man : a chromosomal pictorial legacy. *Science*, **215** : 1525-1530.
- YUNIS, J. J., SAWYER, J. R. and DUNHAM, K. 1980. The striking resemblance of high resolution G-banded chromosomes of man and chimpanzee. *Science*, **208** : 1145-1148.





## CONSERVATION CONSIDERATIONS IN RECENT MAMMAL COLLECTIONS

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### INTRODUCTION

To protect their integrity for scientific research, biological specimens must be preserved with as little alteration as possible. The often striking successes of museum conservators in salvaging art, history, or ethnographic objects may have little application in scientific collections. However, the knowledge acquired by conservators and other researchers about the factors which cause deterioration of organic materials can readily be applied to aid the preservation of Recent mammal specimens.

The increasingly sophisticated research techniques used in mammalogy underscore the need for an approach to collection care which seeks to preserve through preventive conservation and to protect research potential through minimal alteration of the specimen. In the absence of data to prove otherwise, it should be assumed that any reaction a specimen undergoes after it is collected threatens both these goals.

Environmental factors such as light, temperature and humidity, and atmospheric pollutants have been shown to cause damage to other museum objects and have the potential to damage mammal specimens. Materials such as metals, wood, paper, paints or other surface coatings, plastics (including rubber), and chemicals used in preparation and fumigation may also react with specimens and the reactions may be accelerated by environmental factors.

### ENVIRONMENT

#### *Light*

Light has the ability to stimulate both physical and chemical change in objects. When a particle of light, a photon, is absorbed by a molecule, the molecule reacts to the input of energy by (a) emission of heat, (2) fluorescent emissions, (3) internal chemical change, (4) rupture of chemical bonds, or (5) transfer of energy to another molecule (Feller 1964a).

The deteriorating effects of light on an object vary with the susceptibility of the object to the absorption of radiant energy (Feller, 1964a; Stolow, 1966a). Organic materials are particularly susceptible (Plenderleith and Werner, 1971). Potential for photochemically induced deterioration is also governed by the intensity of the light source, the length of the exposure, and the spectral characteristics of the light (Feller, 1964a, 1964b; Stolow, 1966a, 1966b).

Portions of the electromagnetic spectrum of particular interest to museums are the wavelengths from 300-1000 millimicrons. This includes visible light and parts of adjacent infrared and ultraviolet regions as shown in Fig. 1. The light sources most commonly encountered in scientific collections are (1) incandescent lamps which have a high output in the infrared, but are low in ultraviolet emissions, (2) fluorescent tube fixtures which emit substantial ultraviolet radiation but are low in infrared, and (3) daylight passing through windows or skylights which transmit both ultraviolet and infrared radiation (Feller, 1968; Lull and Merk, 1982). During collecting, specimens may also be exposed to direct sunlight.

When the low energy photons in the infrared wavelengths (700-1000  $m\mu$ ) are absorbed by an object, they rapidly and efficiently generate heat, stimulating physical deterioration through desiccation and embrittlement (Feller, 1968; Lull and Merk, 1982; Macleod, 1975). In fresh skin, the infrared radiation in sunlight rapidly dries exterior surfaces, trapping moisture and bacteria inside the skin where they cause decomposition of the tissue (Bienkiewicz, 1983; Tancous *et al.*, 1959). The heating effects of infrared radiation promote deformation of anisotropic materials such as bone and ivory (Plenderleith and Werner, 1971) and cause colour change in ivory (Brill, 1980).

Light in the visible range (400-700  $m\mu$ ) is capable of producing photochemical activity. However, it is the shorter wavelengths of the ultraviolet region (300-400  $m\mu$ ) which are most energetic and are responsible for most photochemical damage (Feller, 1964b; Greathouse *et al.*, 1954; Lull and Merk, 1982; Macleod, 1975).

The disulfide bonds in hair keratin are ruptured and amino acids, especially cystine and tryptophan, are rapidly degraded by ultraviolet light (Lennox and Rowlands, 1969). The interfibrillary proteins of animal skin may be denatured by ultraviolet light and strong ultraviolet radiation breaks down the walls of the fat cells within the skin, permitting the fats to ooze out into the hair (Balfe, 1948; Lloyd, 1948).

Light in the ultraviolet region degrades the cellulosic polymers of paper used for labels and records (Clapp, 1978). Dyes in paper (for example, the red colourants often used for holotype labels) are degraded

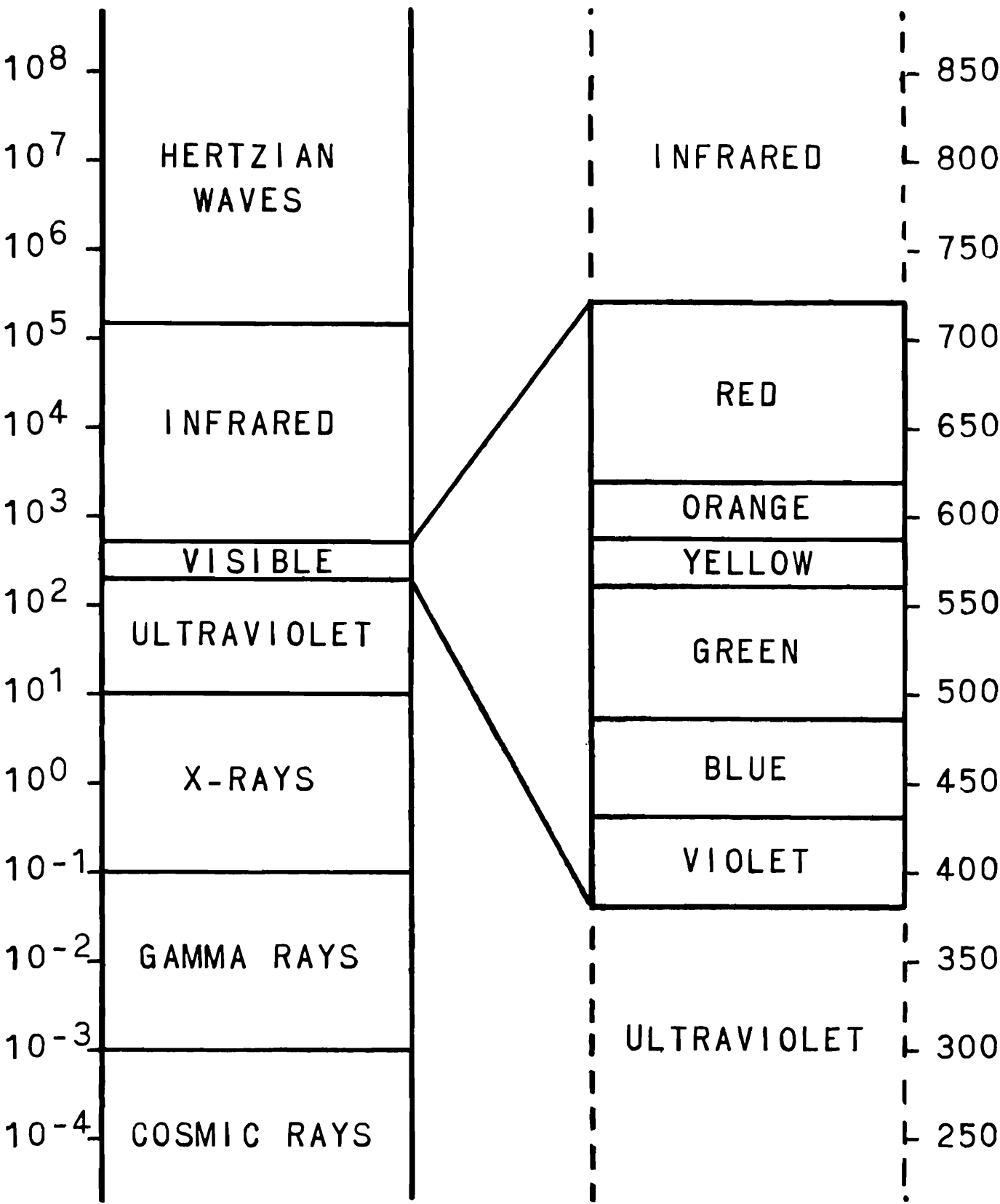


Fig. 1.—Digrammatic representation of electro-magnetic spectrum of light.

by light and contribute to the decay of the paper as they deteriorate (Greathouse *et al.*, 1954). Paper becomes increasingly acidic as it undergoes photochemical decay and the acidity accelerates the degradation of the dye (Brill, 1980). Once photochemical activity has been induced, deterioration will continue even after the paper has been removed from the light (Brill, 1980; Feller, 1964*b*). This suggests that all paper records should be protected from light and pigmented labels should not be used

as original labels for specimens. If red labels are used with holotypes, consideration should be given to replacing them with new labels on a regular basis so that acidic decomposition products do not have an opportunity to migrate into other labels on the specimen, or into the specimens.

Devices to detect and monitor ultraviolet radiation may be constructed or may be purchased commercially (Lafontaine, 1980; Padfield, 1967). Infrared radiation is measured with infrared thermometers and surface temperature probes (Lafontaine, 1980). Light intensity may be measured with a simple light meter of the type used in photography.

Neither infrared nor ultraviolet radiation is visible to the human eye. Therefore, neither contributes necessary elements to the lighting for storage, research, and exhibit areas (Macleod, 1975). If incandescent lamps supply lighting, ventilation will be needed to reduce heating effects of the lamps. The ultraviolet radiation of fluorescent fixtures can be filtered with rigid plastic filters or with flexible plastic filters which fit over the fluorescent tubes (Macleod, 1975; Smithsonian, 1982). Windows may also be fitted with rigid plastic filters or covered with shades, drapes, or venetian blinds which will also reduce the intensity of incoming light (Stolow, 1966b).

Lull and Merk (1982) recommend that paper not be exposed to light intensities above 50 lux and that bone, ivory, horn, leather, fur, and skin should not be exposed to intensities above 150 lux. The amount of lighting needed can be reduced by reflecting the available light on glossy white surfaces. The use of paint containing zinc oxide or titanium dioxide pigments is recommended because these pigments absorb ultraviolet radiation (Feller, 1964a; Macleod, 1975). Zinc oxide pigments help inhibit the growth of mould on paint surfaces and may be preferred for use in the tropics (Whiteley, 1966).

The length of exposure to light may be reduced by storing specimens in light-proof cases and by keeping specimens covered when outside the cases. Lighting in any collection area should be extinguished when the area is not in use.

Photochemical damage is usually irreversible and is accelerated by other environmental factors (Feller, 1964a).

### *Temperature and Humidity*

Few mammal collections enjoy the complete climate control provided for many art and history collections. The environment surrounding scientific specimens often reflects the climate in which the museum is

located. Seasonal extremes may be modified by heating and/or air conditioning, but these are often used only during working hours, allowing both temperature and relative humidity to fluctuate over a broad range on a diurnal basis.

Study skins, tanned hides, bone, and ivory are hygroscopic materials, that is, they give up or take on moisture until they reach an equilibrium with the moisture content of the surrounding air (Buck, 1964; Macleod, 1978; Stolow, 1966c). Each change in relative humidity subjects the specimens to dimensional changes. In the absence of a well controlled environment, changes are apt to take place overnight or within a matter of days. Anisotropic materials, such as bone and ivory, respond to dimensional change in more than one direction and rapid fluctuations in relative humidity may cause them to warp, crack, or split (Werner, 1968). Study skins are composed of a variety of materials, each of which may react to humidity fluctuations at differing rates, amounts or directions, subjecting the skins to uneven stress (Bromelle, 1968; Johnson and Horgan, 1979; Macleod, 1978).

Prolonged exposure to extremely low or high relative humidity may be damaging to some specimens. At very low humidity animal hair is subject to matting and felting from static electricity (Kaplan, 1971). Stambolov (1969) states that at relative humidities below 50%, tanned skin becomes brittle as loss of water content leads to a decrease in physical strength.

Relative humidities above 65% are associated with the growth of mould and mildew (Florian, 1976; Macleod, 1978; Stambolov, 1969). Although mould and mildew yield to a variety of chemical treatments (Bienkiewicz, 1983, Dahl, 1957; Florian, 1976), it is certainly preferable to avoid the need for fungicides.

Temperature alone is important primarily for its effect on relative humidity. Gradual temperature changes have little effect on most museum objects (Buck, 1964; Johnson and Horgan, 1979). However, when coupled with high humidity, temperatures from 25°C to 30°C are optimal for biological deterioration from mould, mildew, bacteria, and insects (Coremans, 1968; Wessel and Thom, 1954), and temperatures from 30°C to 40°C are damaging to tanned skins (Bowes and Raistrick, 1967). Every 10°C rise in temperature normally doubles the rate of chemical reactions, accelerating the deterioration caused by other environmental factors or by reactions with other materials (Bromelle, 1968; Buck, 1964; Johnson and Horgan, 1979).

At very low temperatures (below freezing) untanned skins become fragile and are easily damaged in handling (Bienkiewicz, 1983). At low

temperatures tin, which is sometimes used for specimen labels, changes from a crystalline metal to a grayish powder and should not be used with specimens which will be frozen, refrigerated or exposed to low temperatures in unheated storage facilities.

Temperature and relative humidity readings may be taken by a variety of methods. Hygrothermographs are expensive, but are accurate and require little staff time. They produce a graph depicting both factors, 24 hours a day, for a period of up to two weeks. Thermohygrometers are less expensive but must be monitored manually. Temperature alone can be monitored with standard thermometers or maximum-minimum thermometers. Relative humidity can be measured with Assman-type or sling psychrometers, hygrometers, and paper indicator strips impregnated with cobalt salts. Plenderleith and Philippot (1960), Lafontaine (1980), and Macleod (1978) give detailed reviews of monitoring devices for museum environments.

Limiting the frequency and range of fluctuations in temperature and humidity are the most important considerations for museums. Where possible, temperatures should be compatible with human comfort, about 20-23°C, and should be maintained within a range of about 5°C (Buck, 1964). Seasonal relative humidity changes should not exceed 20% and diurnal changes should be substantially less (Buck, 1964). A range of 45-65% (Buck, 1964; Macleod, 1978) or 40-60% (Johnson and Horgan, 1979; Smithsonian, 1978a) might be acceptable for most mammal specimens.

A facility designed to incorporate complete climate control allows specimens to be transferred in and out of exhibit or storage areas without risk. However, fully controlled environment is difficult to introduce into an existing building and may cause physical damage to the structure (Admur, 1964; Coremans, 1968). Admur (1964) describes methods to achieve climate control on a room or isolated area basis.

Inside sealed storage or exhibit cases it is possible to create a microclimate in which relative humidity is independent of the external humidity levels and in which an increase in external temperature will result in a gradual increase of internal relative humidity (Stolow, 1966d; 1977). The microenvironment can be created by using pre-conditioned silica gel as a desiccant or humectant. Silica gel is chemically and physically inert and may be repeatedly regenerated by oven drying at 250°C (Smithsonian, 1978b, 1981; Stolow, 1977). The amount of silica gel needed will vary with the amount of other hygroscopic material in the case and it will require some experimentation to determine an appropriate amount. However this is one of the least expensive methods of climate control (Stolow, 1977).

*Atmospheric Pollutants*

The atmosphere around any museum may have gaseous or particulate components detrimental to natural history collections. In coastal areas the atmosphere contains chlorides which may recrystallise on objects. These chlorides are hygroscopic particles that will attract moisture and may attract and hold other pollutants (Bromelle, 1968; Plenderleith and Werner, 1971). Saline impurities in the air may corrode iron or brass tail and leg supports in study skins, and the zinc and steel used for storage cases (Greathouse *et al.*, 1954; Yocom and Upham, 1977).

Rural atmospheres contain dust (acid or alkaline, depending upon the parent soil) and mould spores (Greathouse *et al.*, 1954). Acids cause hydrolysis of paper records and labels (Clapp, 1978). Alkalies degrade pigment granules in animal hair (Kidd, 1977). Dust may be abrasive and can serve as a nutrient for microorganisms (Wessel, 1954; Yocom and Upham, 1977). Mould spores can regenerate on hygroscopic materials (Ayerst, 1966; Stolow, 1966c).

Urban atmospheres may contain hydrogen sulfide, sulfur dioxide, nitrogen oxides, high levels of ozone, and sooty, tarry or abrasive particulates (Bromelle, 1968, Greathouse *et al.*, 1954; Plenderleith and Philip-pot, 1960; Plenderleith and Werner, 1971). Hydrogen sulfide damages paint finishes and most metals (Yocom and Upham, 1977). Sulfur dioxide is absorbed into protein and cellulosic materials where it combines with moisture to produce sulfurous acid, which in turn oxidises to sulfuric acid, and ultimately disintegrates the materials (Plenderleith and Werner, 1971, Yocom and Upham, 1977). Hydrogen sulfide, nitrogen oxides, and ozone damage paper (Clapp, 1978), and ozone degrades paint and rubber (Yocom and Upham, 1977). Particulate pollutants absorb moisture and gaseous pollutants and hold them on the specimens (Bromelle, 1968).

Lafontaine (1980) discusses methods of measuring air pollutants. Yocom *et al.* (1977) describe the relationship of outdoor pollutant levels to indoor environments and note that particulates can be reduced by keeping windows and doors closed and using adequate filters for incoming air. Dust covers of cotton muslin or muslin covered with polyethylene sheeting may be used for materials stored on open shelves (Johnson and Horgan, 1979).

Control of gaseous pollutants requires air conditioning which recirculates air and includes filters, air washing and activated carbon absorption (Yocom *et al.*, 1977; Bromelle, 1968).



## MATERIALS

### *Wood*

Storage cases for mammal specimens are usually fitted with wooden drawers. Wood offers some cushioning properties and may help hold moisture in creating a microclimate (Stolow, 1966*d*, 1977), but once exposed to light, wood surfaces are photooxidised, resulting in an increase in the acidity of the wood and the formation of volatile degradation products including carbon monoxide, methanol, formaldehyde and organic acids (Hon *et al.*, 1980; Kalnins, 1966).

Wagstaffe and Fidler (1968) associate the use of wooden storage drawers with foxing (fading) of animal hair. Formaldehyde causes formation of new disulfide bonds in hair keratin (Stoves, 1947). Contact with acidic materials may damage leather (Stambolov, 1969; Tancous *et al.*, 1959) and will eventually destroy paper used for labels (Clapp, 1978; Wessel, 1954).

Personal communication with representatives of the U. S. National Bureau of Standards, the U. S. Forests Products Laboratory and the Paint Research Association, Middlesex, England revealed that no coating will completely eliminate the emission of volatiles from wood. These agencies recommended two-component epoxy or polyurethane systems for coating storage drawers. Both systems are solvent, chemical, water and abrasion resistant (Miles and Briston, 1979).

As an alternative to wood, metal drawers with a baked enamel finish may be used in storage cases. Baked enamels are superior to air dry finishes for abrasion and chemical resistance (Cowling and Roberts, 1954; Schur, 1975). If wood cannot be coated or replaced, it may be lined with a non-reactive material to help protect the specimens. Liners made with the "acid-free" papers available from conservation materials suppliers are not recommended because these are usually alkaline buffered to a pH of about 8.5 and may be detrimental to protein based materials preserved for scientific research.

### *Plastics (Including Rubber)*

Clear polyester film without additives (for example, plasticizers or ultraviolet inhibitors) is a tough, abrasion and chemical resistant material which can be used to create envelopes to protect fragile papers (Library of Congress, 1980). The film can also be used to line wooden storage drawers or shelving, although it may generate static electricity in dry environments.

High density expanded polyethylene foams are resistant to moisture, strong alkalies and most organic acids, are insoluble in all solvents at temperatures below 80°C, have excellent cushioning properties and provide a non-abrasive, non-skid surface (Dow Chemical Company, 1969; Mellan, 1976; Miles and Briston, 1979). These properties make it an excellent material for lining wooden drawers and shelves. Experiments at The Carnegie Museum of Natural History show that polyethylene foam melts at temperatures below those at which mammal study skins are damaged by heat. However, the tests indicate that temperatures above 140°C are necessary before this presents a serious problem.

Rubber products are usually found in mammal collections as door seals for storage cases and as stoppers for fluid preserved specimens. Natural rubbers have good resistance to alkalies and dilute acids, but resistance to some hydrocarbon solvents is poor (Miles and Briston, 1979), an important factor where fumigants based on hydrocarbons are used. Levi (1966) reports that rubber stoppers dissolve in alcohol, lower the pH of the fluid and deposit sulfur crystals on specimens.

Polychloroprene (neoprene) is a synthetic rubber resistant to flame, abrasion, oils, greases, most solvents, dilute and concentrated acids, microbiological attack and ozone, and has a low permeability to gases (Allen, 1972; Lightbody *et al.*, 1954; MacLachlan *et al.*, 1966; Miles and Briston, 1979). These properties make it a good choice for door seals on storage cases. However, Levi (1966) notes that neoprene stoppers have leached antioxidants into the alcohol of fluid preserved specimens.

### *Paper*

Specimen trays, boxes for skeletal material and most specimen labels are made of paper or paperboard. In addition to deterioration by environmental factors, paper is degraded by contact with acidic materials and by acidic substances incorporated into the paper during manufacture, including acid-inducing metallic salts, residues from bleaches, non-cellulosic components of the wood pulp, and acidic sizings (Clapp, 1978). Whatever the source of the acidity, a pH below 5.5 is considered to be a critical stage in the deterioration of paper (Plenderleith and Werner, 1971). Papers with an all-rag content or produced from highly chemically purified wood fibers seem to be among the best in terms of permanence (Wessel, 1954).

Acids in specimen trays and boxes will migrate into the paper labels on specimens (Clapp, 1978) and will damage the inorganic portion of bone and ivory (Goffer, 1980; Plenderleith and Werner, 1971).

Clapp (1978) describes a variety of pH testing kits and devices available from conservation materials suppliers. The pH of a random sampling of all incoming shipments of paper boxes trays and labels should be taken when the materials are received and the samples should be reserved for future tests to determine the pH of these materials as they age. If pH decreases over time, old boxes and trays should be replaced with new ones, or should be lined with non-reactive materials.

“Acid-free” papers buffered to a pH about 8.5 may be used as the paper for permanent collection records and “acid-free” file boxes may be used to store field records. Alkaline buffering has been shown to be beneficial in the preservation of many cellulosic materials (Clapp, 1978).

### *Paints and Coatings*

Coatings are usually comprised of a pigment, a vehicle (drying oil or resin), solvents, plasticizers, driers (metals combined with organic acids to form metallic soaps), and a variety of additives for special properties (Cowling and Roberts, 1954; Robinson, 1981). Many of these components are designed to volatilise as part of the curing of the coating and coatings oxidise naturally as they age (Cowling and Roberts, 1954). The impact of these volatile products on mammal specimens is unknown.

Titanium dioxide pigments are the least reactive white pigments and have excellent chemical resistance, while many coloured pigments are attacked by solvents (Clark, 1975; Singer, 1981). Organic vehicles and plasticizers serve as nutrients for mould and mildew (Cowling and Roberts, 1954).

Manufacturers can provide technical data on the properties and components of coatings. This data, along with information on when, how and where coatings were applied should be part of the records pertaining to a collection.

### *Metals*

Steel, iron, zinc, tin, brass, and monel are a few of the metals used with or near mammal specimens. Metals react with their environment to form thin films of oxides, sulfides, chlorides or carbonates. Corrosion becomes active when films are discontinuous, or when hygroscopic dust or traces of fatty matter provide enough moisture for corrosion reactions to occur (Plenderleith and Toracca, 1968; Promisel and Mustin, 1954). When dissimilar metals are in contact either directly or through an electrolyte, a current flows between them and the metal having the highest electrochemical potential is preferentially corroded (Goffer, 1980; Promisel and Mustin, 1954). Painted metals are subject to corrosion whenever

the paint surface is disrupted by nicks or scratches and once corrosion begins, it will spread underneath the rest of the coating (Cowling and Roberts, 1954).

Bone and ivory are readily stained by corrosion products (Johnson and Horgan, 1979). Animal skin may be rendered resistant to biological decay by metallic salts, but will be stained in the process (Plenderleith and Werner, 1971). Iron particles from corrosion of iron and steel not only stain, but catalyse the change of sulfur dioxide to sulfuric acid (Clapp, 1978).

Monel, a nickel-copper alloy which has been used for labels, storage tanks for fluid preserved specimens, and tail and leg wires in study skins, is resistant to zinc chloride, fatty acids, most other organic acids and many alkalies. However it is not resistant to sulfurous acid, ammonia solutions and hypochlorite bleaches (Mogerman and LaQue, 1950).

### *Preparation Chemicals and Fumigants*

Study skins have been treated with arsenic compounds, sodium fluosilicate, borax, zinc chloride, alums, salt, magnesium carbonate, formalin and mercury compounds, to name a few. Skeletal material may have been cleaned with borates, ammonia compounds, enzymes, sodium hypochlorite or various combinations of the above and other chemicals. Tanned skins may have undergone a formidable variety of chemical processes. Specimens have been preserved in a great number of different fluid mediums over time, although the most common technique involves formalin followed by tap water, then ethyl or isopropyl alcohol.

Coetzee (1985) and Downing (1945), among others, have made contributions to understanding the effects of selected chemicals on colour change in study skins. The underlying chemical alteration of the specimens which are reflected in these changes have not been documented. Certainly the selection of preparation materials should be aimed at maximum preservation with minimal alteration of the specimens. Unfortunately, much of the basic research needed to achieve this goal is not available at this time.

There is a need for records documenting the preparation materials used with particular specimens. This will allow researchers to assess the value of a specimen for their research requirements and will provide a data base for evaluating the effects of the materials on the long term preservation of the specimens. A simple description of each preparator's methods should be part of the permanent records for a collection. Brief notations on any variations from the standard methods could be added to pertinent field records.

The same considerations should be applied to fumigant chemicals, many of which are solvents (for example, carbon tetrachloride and ethylene dichloride). Although the effects of these fumigants on human health and on a variety of materials have been documented to some degree, the reactions between these chemicals and the specimens are not well understood. Specimens may have been exposed to a number of different fumigants, as well as a number of different preparation chemicals. The effects of these combinations are also unknown.

Permanent records which document fumigation procedures will help provide the data necessary to understand the long term effects of the fumigants on the specimens.

#### SUMMARY

Recent mammal collections are threatened as museum objects and as scientific research specimens by environmental factors such as light, temperature, relative humidity, and atmospheric pollutants. Materials sharing an environment with collections may react with specimens, altering their integrity for scientific research and jeopardising their preservation.

Organic materials are particularly sensitive to light. Infrared wavelengths cause desiccation of fibrous proteins and mechanical deformation of anisotropic materials such as bone and ivory. Ultraviolet radiation degrades amino acids, denatures fibrous proteins, and weakens papers used for labels and records. Light damage is reduced by limiting the length of exposure, reducing intensity of sources and using ultraviolet filters.

Mammal specimens are composites of hygroscopic materials which undergo uneven dimensional changes as humidity fluctuates. High temperatures accelerate chemical reactions, desiccate tissues, and coupled with high humidity, promote growth of microorganisms. Control of the range and frequency of temperature and humidity changes should be at the building or room level. Where this is not possible, control can be achieved by creating microclimates inside storage cases.

Atmospheric pollutants are both particulate and gaseous in nature. Particulate pollutants are abrasive and/or hygroscopic. They may hold atmospheric sulfur dioxide which can convert to sulfuric acid. Gaseous pollutants require chemical filters. Specimens can be protected from particulates by mechanical filters and dust covers.

Materials used with specimens for preparation, storage and fumigation must be carefully recorded since most of these materials may react in some way with the specimens. Metals may undergo electrolytic reactions in the presence of moisture, permitting corrosion products to deposit on specimens. Wood exudes a number of volatile products, including organic acids. Paperboard specimen trays and paper labels are often acidic and become more acidic over time. Paints and varnishes contain volatile compounds. The long term reactions between specimens and various insecticides have never been rigorously explored, but the chemicals involved are often highly reactive.

The effects of the interaction between Recent mammal specimens and environmental factors, and between specimens and materials sharing the same environment have never been quantitatively analysed. There is evidence to show that interactions exist and that they may threaten both the scientific integrity and the preservation of the specimens. The damage from these factors is insidious because it is often imperceptible on a day to day, or even a year to year basis.

Any alteration to a specimen, however subtle or inconspicuous, has the potential to destroy the value of that specimen for the increasingly sophisticated analyses used in modern research.

Collection care should be aimed at producing a stable, non-reactive environment for the specimens. All factors which may alter the specimens should be carefully documented.

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#### REFERENCES

- ADMUR, E. J. 1964. Humidity control-isolated area plan. Part II. *Tech. Suppl. Mus. News*, 6 : 58-60.
- ALLEN, P. W. 1972. *Natural Rubber and the Synthetics* : 1-255. Crosby Lockwood, London.

- AYERST, G. 1966. The influence of physical factors on deterioration by mould. In : *Microbiological Deterioration in the Tropics. SCI Monograph No. 23* : 14-20. Society of the Chemical Industry, London.
- BALFE, M. P. 1948. The chemistry of the natural grease of hides and skins. In : *Progress in Leather Science 1920-1945* : 95-99. British Leather Manufacturer's Research Association, London.
- BIENKIEWICZ, K. 1983. *Physical Chemistry of Leather Making* : 1-541. Robert E. Krieger Publishing Co., Malabar, Florida.
- BOWES, J. H. and RAISTRICK, A. S. 1967. The action of heat and moisture on leather, Part VI. *JALCA*, **62**(4) : 240-257.
- BRILL, T. B. 1980. *Light-Its Interaction with Art and Antiquities* : xi+1-287. Plenum Press, New York.
- BROMELLE, N. S. 1968. Lighting, air-conditioning, exhibition, storage, handling and packing. *UNESCO Mus. Monu. Ser.*, **11** : 291-301.
- BUCK, R. D. 1964. A specification for museum air conditioning. Part I. *Tech. Suppl. Mus. News*, **6** : 53-57.
- CLAPP, A. F. 1978. *Curatorial Care of Works of Art on Paper* (3rd rev. ed.) : iv+1-135. Intermuseum Conservation Association, Oberlin, Ohio.
- CLARK, H. B. 1975. Titanium dioxide pigments. In : *Treatise on Coatings, Volume 3, Part I* : 479-532. Marcel Dekker, New York.
- COETZEE, C. G. 1985. The influence of preservatives on coat color of small mammals.—*Acta. Zool. Fennica*, **170** : 67-68.
- COREMANS, P. 1968. Climate and microclimate. *UNESCO Mus. Monu. Ser.*, **11** : 27-39.
- COWLING, J. E. and ROBERTS, M. E. 1954. Paints, varnishes, enamels and lacquers. In : *Deterioration of Materials* : 596-645. Reinhold Publishing Corp., New York.
- DAHL, S. 1957. The effects of fungicides on deterioration of leather. *JALCA*, **52**(11) : 611-621.
- Dow Chemical Company. 1969. *Packaging with Ethafoam* : 1-20, Dow Chemical Company, Midland, Michigan.

- DOWNING, S. C. 1945. Color changes in mammal skins during preparation. *J. Mammal.*, **26**(2) : 128-132.
- FELLER, R. L. 1964a. Control of deteriorating effects of light on museum objects. *Museum*, **17**(2) : 71-98.
- FELLER, R. L. 1964b. The deteriorating effect of light on museum objects : principles of photochemistry. *Tech. Suppl. Mus. News*, **3** : 1-8.
- FELLER, R. L. 1968. Control of deteriorating effects of light upon museum objects : heating effects of illumination by incandescent lamps. *Tech. Suppl. Mus. News*, **46**(9) : 39-47.
- FLORIAN, M. E. 1976. Fungicide treatment of eskimo skin and fur artifacts. *J. IIC-Can. Group*, **2**(91) : 10-17.
- GOFFER, Z. 1980. *Archaeological Chemistry* : xvi+1-376. John Wiley & Sons, New York.
- GREATHOUSE, G. A., FLEER, B. and WESSEL, C. J. 1954. Chemical and physical agents of deterioration. In : *Deterioration of Materials* : 71-174. Reinhold Publishing Corp., New York.
- HON, D. N-S., IFU, G. and FEIST, W. C. 1980. Characteristics of free radicals in wood. *Wood and Fiber*, **12**(2) : 121-130.
- JOHNSON, E. V and HORGAN, J. C. 1979. Museum collection storage. *UNESCO Tech. Handb. Mus. Monu.*, **2** : 1-56.
- KALNINS, M. A. 1966. Surface characteristics of wood as they affect durability of finishes. Part II. Photochemical degradation of wood. *Res. Pap. U. S. Forest Serv. FPL*, **57** : 23-60.
- KAPLAN, H. 1971. *Fur skin Processing* : xv+1-231. Pergamon Press, New York.
- KIDD, F. 1977. Other animal fibers. In: *Chemistry of Natural Protein Fibers* : 371-407. Plenum Press, New York.
- LAFONTAINE, R. H. 1980. Recommended environmental monitors for museums, archives and art galleries. *Tech. Bull. Can. Conserv. Inst.*, **3** : 1-15.
- LEVI, H. W. 1966. The care of alcoholic collections of small invertebrates. *Syst. Zool.*, **15** : 183-188.



- LENNOX, F. G. and ROWLANDS, R. J. 1969. Photochemical degradation of keratins. *Photochem. Photobiol.*, **9** : 359-367.
- LIBRARY OF CONGRESS. 1980. *Polyester Film Encapsulation* : iii+1-23, U. S. Library of Congress, Washington, D. C.
- LIGHTBODY, A. E., ROBERTS, M. E. and WESSEL, C. J. 1954. Plastics and rubber. In : *Deterioration of Materials* : 537-595. Reinhold Publishing Corp., New York.
- LLOYD, D. J. 1948. The curing and soaking of hides and skins. In : *Progress in Leather Science 1920-1945* : 130-155. British Leather Manufacturers' Research Association, London.
- LULL, W. P. and MERK. 1982. Lighting for storage of museum collections. *Tech. Conserv.*, **7**(2) : 20-25.
- MACLACHLAN, J., Heap, W. M. and PACITTI, J. 1966. Attack of bacteria and fungi on rubbers and plastics in the tropics. In : *Microbiological Deterioration in the Tropics. SCI Monograph No. 23* : 185-200. Society of the Chemical Industry, London.
- MACLEOD, K. J. 1975. Museum lighting. *Tech. Bull. Can. Conserv. Inst.*, **2** : 1-13.
- MACLEOD, K. J. 1978. Relative humidity, its importance, measurement and control in museums. *Tech. Bull. Can. Conserv. Inst.*, **1**:1-41.
- MELLAN, I. 1976. *Corrosion Resistant Materials Handbook* : x+1-685. Noyes Dtta Corp, Park Ridge, New Jersey.
- MILES, D. C. and Briston, J. H. 1979. *Polymer Technology* : 1-707. Chemical Publishing Co., Inc., New York.
- MOGERMAN, W. D. and LAQUE, F. L. 1950. *Nickel, Monel, Inconel* : 1-48. International Nickel Co., New York.
- PADFIELD, T. 1967. A simple ultraviolet radiation detector for museum use. *Stud. Conserv.*, **12**(1) : 1-4.
- PLENDERLEITH, H. J. and PHILIPPOT, P. 1960. Climatology and conservation in museums. *Museum*, **13**(4) : 242-289.
- PLENDERLEITH, H. J. and TORACCA, G. 1968. The conservation of metals in the tropics. *UNESCO Mus. Monu. Ser.*, **11** : 237-249.

- PLENDERLEITH, H. J. and WERNER, A. E. 1971 *The Conservation of Antiquities and Works of Art* (2nd ed.): xix+1-394. Oxford University Press, London.
- PROMISEL, N. E. and Mustin, G. S. 1954. Metals. In : *Deterioration of Materials* : 237-307. Reinhold Publishing Corp., New York.
- ROBINSON, J. S. (ed.). 1981. *Paint Additives* : v+1-369. Noyes Data Corp. Park Ridge, New Jersey.
- SCHUR, G. E. 1975. Appliance finishes. In: *Treatise on Coatings Vol. 4, Part 1* : 85-152. Marcel Dekker, New York.
- SINGER, E. 1981. Raw materials. In : *Paint Handbook* (3)1-(3)32. McGraw-Hill Book Co., New York.
- SMITHSONIAN INSTITUTION. 1978a. Conditions for storage and display of museum objects. *Conserv. Analyt. Lab.*, **193** 1
- SMITHSONIAN INSTITUTION. 1978b. To condition silica gel. *Conserv. Analyt. Lab.*, **190** : 1
- SMITHSONIAN INSTITUTION. 1981 Silica gel. *Conserv. Analyt. Lab.*, **44** : 1.
- SMITHSONIAN INSTITUTION. 1982. Manufacturers of UV light absorbing or reflecting coatings, sheets, sleeves. *Conserv. Analyt. Lab.*, **195B** 1
- STAMBOLOV, T 1969. *Manufacture, Deterioration and Preservation of Leather* : ii+1-98. Central Research Laboratory Object Arts Science, Amsterdam.
- STOLOW, N. 1966a. Environmental security. In: *A Primer on Museum Security* : 39-49. New York State Historical Association, Cooperstown, New York.
- STOLOW, N. 1966b. The action of environment on museum objects. Part 2, Light. *Curator*, **9** : 298-306.
- STOLOW, N. 1966c. The action of environment on museum objects. Part 1, Humidity, temperature, atmospheric pollution. *Curator*, **9** : 175-185.
- STOLOW, N. 1966d. Fundamental case design for humidity-sensitive museum collections. *Tech. Suppl. Mus. News*, **11** : 45-52.

- STOLOW, N. 1977. The microclimate, a localized solution. *Mus. News*, **56** : 52-63.
- STOVES, J. L. 1947. Some biological and chemical properties of animal hair. *J. Soc. Dyers Colour.*, **63**(3) : 69-77.
- TANCOUS, J. J., RODDY, W. T and O'FLAHERTY, F. 1959. *Skin, Hide and Leather Defects* : 1-242. Tanners' Council Lab., Cincinnati, Ohio.
- WAGSTAFFE, R. and Fidler, J. H. 1968. *The Preservation of Natural History Specimens, Vol. 2. Part 2, Zoology-Vertebrates* : xv +1-404. Philosophical Library, New York.
- WERNER, A. E. 1968. The conservation of leather, wood, bone and ivory and archival materials. *UNESCO Mus. Monu. Ser.*, **11** : 265-290.
- WESSEL, C. J. 1954. Paper. In : *Deterioration of Materials* : 355-407. Reinhold Publishing Corp., New York.
- WESSEL, C. J. and THOM, H. C. 1954. Climate and deterioration. In : *Deterioration of Materials* : 3-70. Reinhold Publishing Corp., New York.
- WHITELEY, P. 1966. The occurrence and prevention of mould and algal growth on paint films. In : *Microbiological Deterioration in the Tropics. SCI Monograph No. 23* : 161-169. Society of the Chemical Industry, London.
- YOCOM, J. E., Cote, W. A. and Benson, F. B. 1977. Effects on indoor air quality. In : *Air Pollution (3rd ed.)*, Vol. 2 : 117-155. Academic Press, New York.
- YOCOM, J. E. and Upham, J. B. 1977. Effects on economic materials and structures. In : *Air Pollution (3rd ed.)*, Vol. 2 : 65-116. Academic Press, New York.

#### DISCUSSION

- Q. *How and what type of light arrangement do you give to the specimens to bring out its natural colour ?*
- A. You may pick any lighting with a colour temperature designed to enhance the ability of your eyes to see the colour of the specimens.

Dr. Wilson can explain the type of lighting used for this purpose at the U. S. National Museum. However, your eyes cannot see infra-red and most ultraviolet radiation, so light in these ranges contributes nothing to this type of lighting.

*Q. Is there a better desiccant than Silica gel to use for control of humidity levels within specimen-cases ?*

A. There are a number of other desiccants on the market, however, none of them incorporates in a single product all the properties of silica gel. Silica gel is chemically and physically inert and may be repeatedly regenerated by oven drying. Silica gel can also be used as a humectant to raise the relative humidity in dry areas.

*Q. Some people have told us in this conference that they use the sun to dry their specimens and to keep off fungi. What is the minimum sun exposure that can be practiced without damage to the specimens ?*

A. The ultraviolet radiation in sunlight will indeed kill mould and mildew, and some mould and mildew may be killed by the heat generated from infrared wave lengths. I know of no study which addresses the length of exposure to direct sunlight which will harm fresh mammal skins. However, the intensity of direct sunlight means that exposure must be brief (probably under one hour) since damage potential from light is a function of the intensity and the length of exposure.

*Q. In at least one collection of mammals located in a tropical country lime is used in cases as a cheap, de-humidifying compound for very humid conditions. Do you know any harmful effects with this system, and would it be a potential alternative to electric systems of humidity control in developing countries ?*

A. It depends on whether or not the mineral has been calcined. A calcined lime may give off a great amount of heat as it rehydrates. If that is not a problem, lime might be used as a desiccant ; however, it is alkaline and any contact with the specimens should be avoided.



## **STUDY OF PELLETS, FOOT-PRINTS AND PUG-MARKS**

A. K. MANDAL

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In order to know the mammalian fauna of an area the standard method is the collecting of specimens of as many species as possible, and their preservation. However, now-a-days collection of many species of mammals has become prohibited or restricted due to the strict application of wildlife protection acts. As such, the importance of applying alternate methods for recording the presence of various species of mammals in a particular area cannot be overemphasised. Positive identification of a mammalian species based on its specific call is an usual practice at the point. Observation, collection and preservation, whenever feasible, of foot-prints, pug-marks, faecal and bird-pellets, etc., are the other most useful methods for authentically recording species of mammals in an area.

In the present communication, with the help of some illustrative examples, an attempt has been made to show how the study of pellets, foot-prints, and pug-marks can be useful in determining the identity of a species in a given area.

### **PELLETS**

Pellet means the indigestible part of the food material cast out in the form of pills, small balls or lumps from either of the extremities of the alimentary tract. Pellets cast out through the anus of mammals are popularly known as faecal pellets, while those regurgitated by some birds from the proventriculus through the mouth are generally called bird-pellets.

#### *Collection and Preservation*

Collection of pellets can be made with the help of a pair of blunt forceps by applying the slightest possible pressure so as to avoid any possible damage to the shape of the pellet. The pellets thus collected are put in a vial and its mouth securedly closed with a dust-proof lid. Freshly collected pellets can also be kept in a specialised type of plastic bag provided with dust-proof lid. However, the most suitable and convenient way of preservation of pellets is to dry them in air and to store them in paper or plastic bags. Samples of pellet can also be dried in an

oven at 80° to 85°C, for six to ten hours, depending upon the quantity and the water-content of the pellet. The material can now be shifted to plastic containers which, in turn, are sealed for final packing and onward transmission to the laboratory. Fumigation of the pellets with carbon disulphide should preferably be done if these are to be stored for a longer period. These can also be dipped in a solution of celluloid in acetone. Acetone being highly volatile, readily evaporates, resulting in a thin coating of celluloid over each pellet. This coating not only maintains the shape of the pellet for a longer period but also protects the pellet against insect attack. For subsequent parasitological studies of the faecal pellets, however, normally 1% aqueous solution of Formaldehyde is considered as a good preservative. It is, of course, very difficult to avoid disintegration of the pellets in the field during the rainy season. The best method, however, to record the undistorted pellets, is to take photographs before their collection.

### *Faecal Pellets*

In contrast to scats (faeces usually of carnivores) and dung (faeces of bovine artiodactyles, perissodactyles, and of the proboscidiens as well), the faecal pellets (faeces of most of the artiodactyles, rodents and of lagomorphs) are quite distinct.

The pellets of an animal can be easily located in its area of activity, such as its tracks, feeding ground, near salt licks, water sources, etc.

The pioneering works of Bennett, *et al.* (1940) on deer-pellets, Webb (1940) on rodents and rabbit-pellets, Emlen *et al.* (1957) on pellets of small mammals, and Cochran and Stains (1961) on pellets of deer, other large ungulates and of rabbit are worth-mentioning here. Further, pellet group counts have been taken into account for the estimation of food intake along the feeding area of an animal (Korschgen 1971). The differences in size and shape of the pellets particularly in Sambar (*Cervus unicolor*), Spotted Deer (*Cervus axis*) (Fig. 1A), Barking Deer, (*Muntiacus muntjak*) (Fig. 1B) and in different species of antelopes, specially in Chinkara (*Gazella gazella*) (Fig. 1C) are well recognisable. For example, there is little difference in size between the pellets of Barking Deer and Chinkara, but the presence of a characteristic 'beak' in the form of a nodule, in each pellet of the latter is sufficient to isolate it from that of the former. Likewise, identification of many other species of mammals can conveniently be made on the basis of their pellets.

### *Bird Pellets*

Most of the birds of prey (Order Strigiformes, families Tytonidae and Strigidae) herons, bitterns (Order Ciconiiformes, families Ardeidae

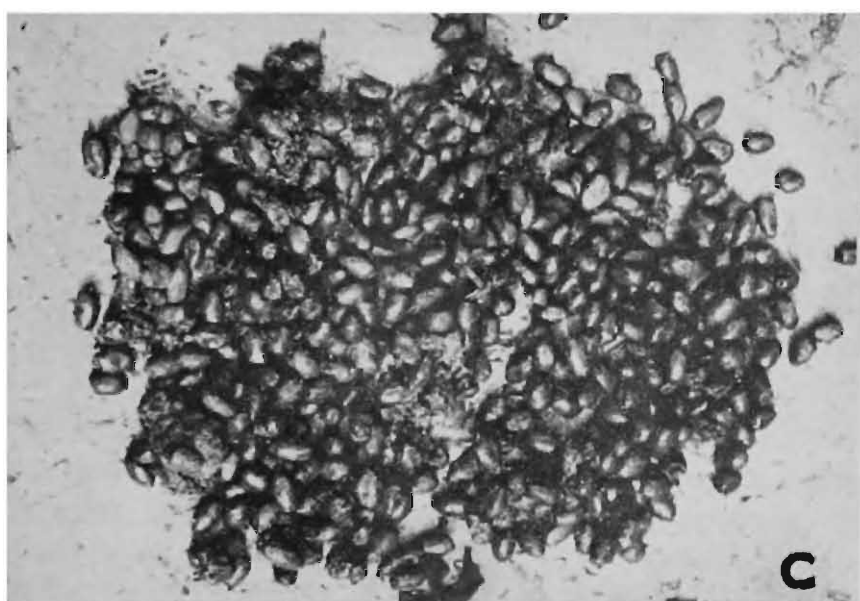
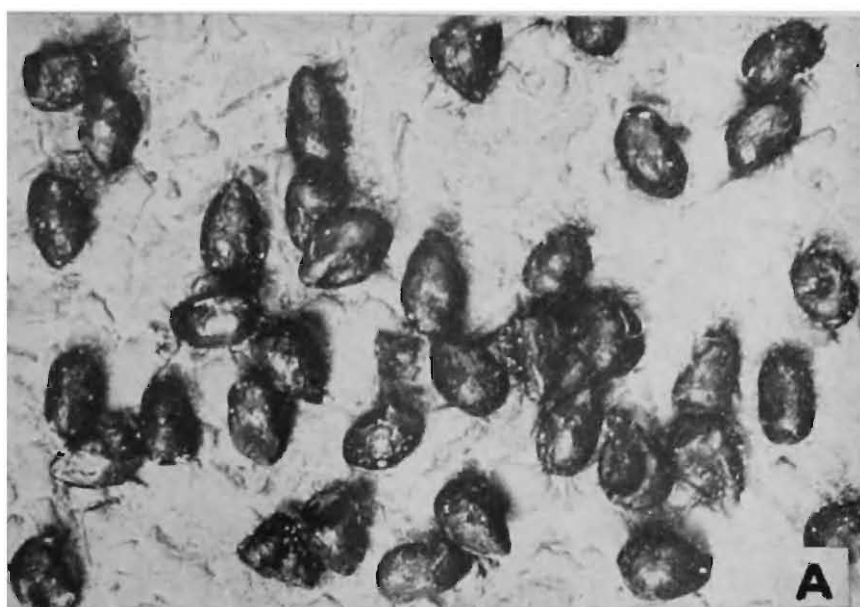


Fig. 1.—Faecal pellets of (A) Spotted Deer, *Cervus axis*, (B) Barking Deer, *Muntiacus muntiac* and (C) Chinkara, *Gazella gazella*



and Ciconiidae) Kestrel and Hobby (Order Falconiformes, Family Falconidae), and nestlings of some Kingfishers (Storkbilled and Brown-winged, Order Piciformes, Family Alcedinidae) are in the habit of throwing the indigestible portion of their meal through the mouth from the proventriculus, in the form of a pellet (Fig. 2A). Bird-pellets contain fur, feather, chitin of insects, bones, pieces of mollusc-shells, etc., which are not broken down by the digestive juices. The pellet is found near the roosting sites, nests, in feeding areas, and in such other suitable places with least human interference. Examination of the pellets provides information about the dietary habit of the bird. Authors like Errington (1930), Wilson (1938), McClure (1945), Banfield (1947), Driver (1949) and Dorney *et al.* (1958) have contributed much in studying pellets of different groups of bird. Khajuria and Ghosal (1970) have studied the pellets of the Barn Owl, *Tyto alba*, in India (Fig. 2B).

Study of bird-pellets, especially the owl-pellet, has some special importance. Owls being nocturnal, their pellets can give an idea as to the smaller mammalian fauna, mainly nocturnal, in its area of activity. By examining owl-pellets one may even come across remnants of such species of mammals as are very difficult, if not impossible, to collect by usual methods, either due to the secretive nature of these animals or due to the inaccessibility of their usual haunt.

#### FOOT-PRINTS AND PUG-MARKS

The foot-print can be defined as an impression or a print formed by the foot, whereas the pug-mark is the impression formed by the paw. Paws are the characteristic features of carnivores, while other groups of animal leave foot-prints along their tracks.

The foot-prints and pug-marks can easily be located on damp or muddy soil, and on sand or snow. The impressions on rocks also can sometimes be obtained if the paws or feet are wet or muddy. A log or such other firm structure on the forest-floor and having a thin layer of mud as a result of flooding due to recent rains, can precisely preserve pug-marks and foot-prints of smaller mammals. Excellent foot-prints and pug-marks could be seen on a sheet of snow lying over a hard substrate. These can also be located along the animal tracks, in the feeding area of an animal or near a source of water. During the dry season when most of the water reservoirs are dried up, even the predator and the prey are compelled to visit the same place wherever there is a trace of water left, for drinking. This may be considered as the ideal spot for the study of foot-prints and pug-marks in that season.

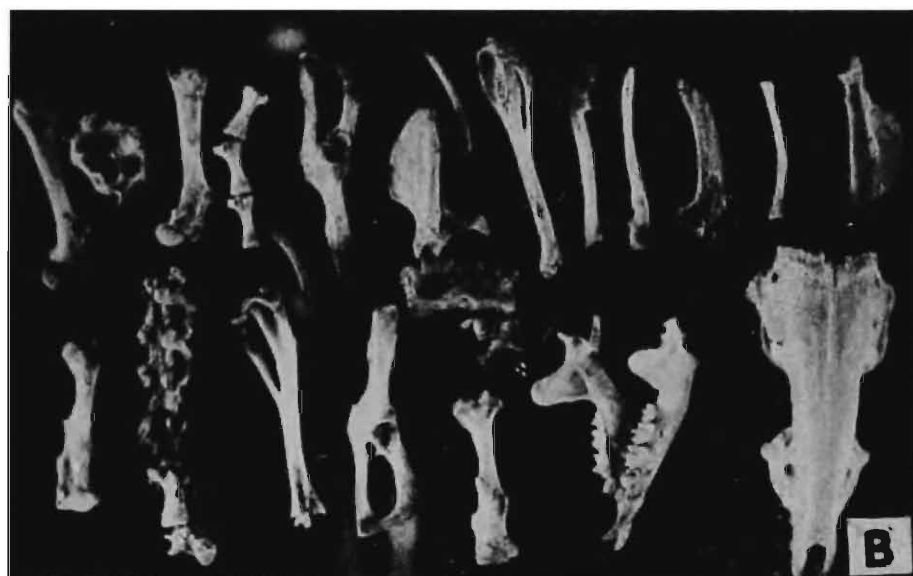


Fig. 2A.—Photograph of entire pellet of the Spotted Owlet, *Athene brama*.

Fig. 2B.—Photograph of the skeletal remains of a House Shrew, *Suncus murinus* recovered from the pellet of the Spotted Owlet, *Athene brama*.

Fig. 2C.—Photograph of the pug-mark of the right hind leg of a tiger.

*Collection and Preservation*

In case of foot-prints and pug-marks, the sketch and/or photograph with scale, as also their casts, may be taken in the field. Measurements of different parts of foot-prints and pug-marks should also be noted. Paraffin wax or Plaster of Paris can be used for making casts. Before making any cast, a well-defined impression should be chosen and loose soil or dried leaves over it should be removed so that the contour of the impression may not be changed. The foot-print or the pug-mark is to be surrounded by a suitable strip of card board or metal foil folded to form a rectangular frame and pressed on the ground. Melted paraffin or Plaster of Paris mixed thoroughly with water is to be poured carefully over the impression surrounded by the frame. After 10 to 20 minutes the hardened cast can be taken out. Loose soil adhered to it can be removed under running water. For the safety of the cast during transport, it should be re-enforced with suitable pieces of steel wire netting. If required, positive casts may be prepared from the negative one made in the field. In that case, the surface of the negative cast is to be rinsed with an aqueous solution of Potash. Vaseline can also be used instead of Potash solution. These casts can now be stored in boxes.

Stewart (1912) was one of the pioneers who published an account on foot-prints of animals. Subsequently, much work was done by Mason (1943) and Drothy (1945) on animal tracks. A detailed account can also be had from Murie (1954). Bang and Dahlstorn (1974) and Brown *et al.* (1984) have contributed much on animal tracks and signs of British and European birds and mammals.

It has authentically been proved that in some animals the pug-marks of the left hind leg can reflect even the age and sex. As for example, in the case of the tiger the pug-marks of the left hind leg of the male is square in shape while that of the female rectangular. The sketch of the pug-mark of the left hind leg of a tiger (Fig. 3A) and that of a tigress (Fig. 3B), and a photograph (Fig. 2C) of the right hind leg of a tiger, obtained during the 'Tiger Census' in the Sundarbans Tiger Reserve, West Bengal, India, clearly show the differences in the pug-marks due to sex. The well-known method of estimating population by counting pug-marks is another aspect of the study of pug-marks to be mentioned here.

Since the study of faecal pellets, bird pellets, foot-prints and pug-marks can give some idea regarding the mammalian fauna of a particular area, it is desirable that a standard atlas may be prepared out of these subsidiary evidences and kept in the museum along with the specimens. For the preparation of this atlas initially representative samples from the zoo animals can be utilised. Once prepared, the atlas will be of tremendous help to the field workers engaged in the study of wildlife.

In this paper, a brief account on the importance and method of studying the different type of pellets as well as foot-prints and pug-marks of animals has been dealt with. Further, it is proposed that a standard atlas should be prepared out of these subsidiary evidences and kept in the museum along with the specimens.

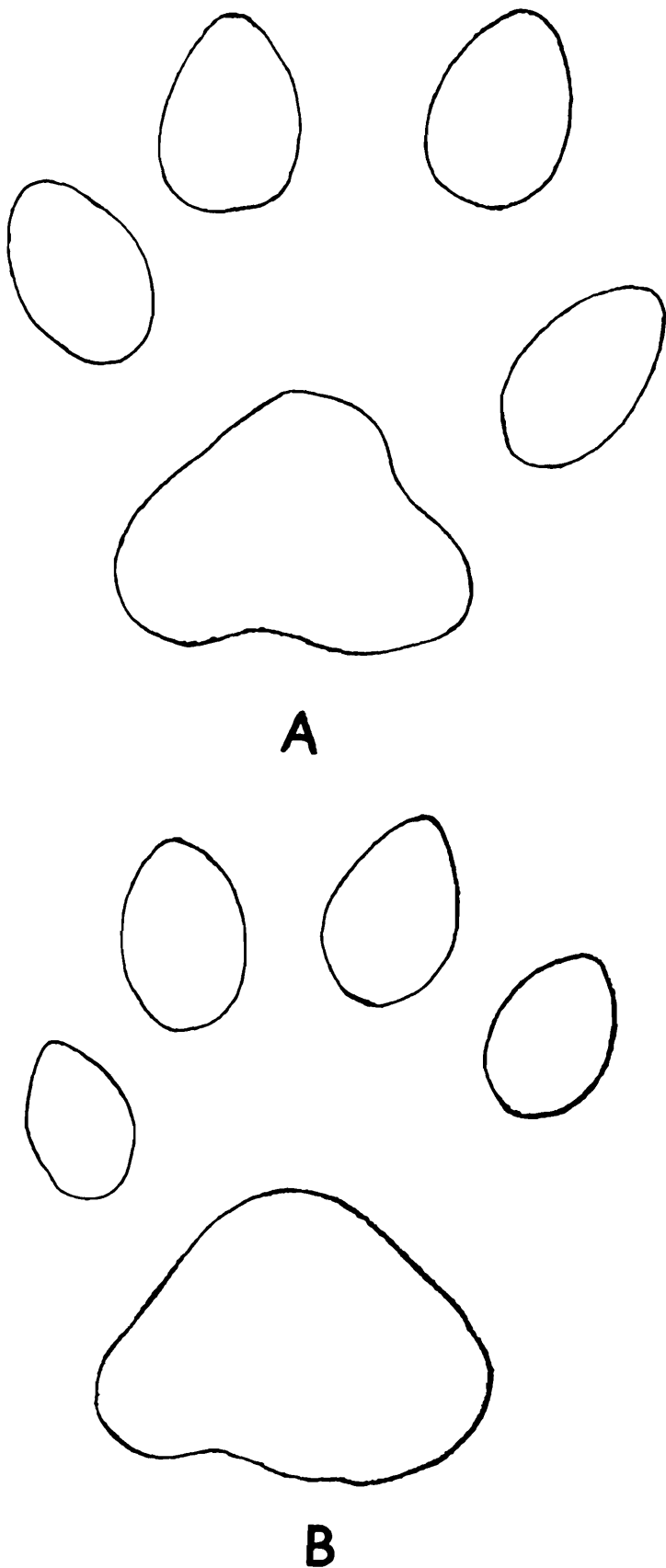


Fig. 3.—Sketch of the pug-mark of the left hind leg of a (A) tiger and (B) tigress.

## SUMMARY

In order to know the representative fauna of a particular area the collection of animals is generally made ; authentic sighting or the call of an animal is also taken into account. When all these positive evidences fail some alternative methods can be thought of, which may give an idea about the faunal component of a place. Initially, the study of faecal pellets and bird pellets can be taken up. The faecal pellets, their shape and size, particularly in artiodactyls, provide sufficient information to identify species. On the other hand, the bird pellets and their contents can clearly indicate about the nocturnal fauna, especially the smaller ones, occurring in the activity area of a bird. Special emphasis may be given to the well known method of studying the foot-prints and pug-marks of animals in determining their age, sex, population-size, etc., in many cases.

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## REFERENCES

- BANFIELD, A. W. F. 1947. A study of the winter feeding habits of Short-eared Owl (*Asio flammeus*) in the Toronto Region, *Can. J. Res.*, **25** : 45-65.
- BANG, P. and DAHISTRON, P. 1974. *Collins Guide to animal tracks and signs*. Collins, London.
- BENNETT, L. J., ENGLISH, P. F. and MC CHAIN, R. 1940. A study of deer populations by use of pellet group counts. *J. Wildl. Mgmt.*, **4** : 398-403.
- BROWN, R. W., LAWRENCE, M. J. and POPE, J. 1984. *The county life guide to animals of Britain and Europe, their tracks, trails and signs*. County Life Books, London.
- COCHRAN, G. A. and STAINS, H. J. 1961. Deposition and decomposition of faecal pellets by collections. *J. Wildl. Mgmt.*, **25** : 432-435.
- DORNEY, R. S., THOMPSON, D. R., HALE, J. R. and WENDT, R. F. 1958. An evaluation of Ruffed Grouse drumming counts. *J. Wildl. Mgmt.*, **22** : 35-40.

- DRIVER, E. C. 1949. Mammal remains in owl pellets. *Am. Midl. Nat.*, **41** : 139-142.
- DROTHY, A. 1945. Track stories in mud, sand and snow. *Tract. School Nature League Bull. New York*, Ser. 16, publ. 4, pp. 4.
- EMLLEN, J., RUTH HINE, T., FULLER, W. A. and ALFONSO, P. 1957. Dropping boards for population studies of small mammals. *J. Wildl. Mgmt.*, **21** : 330-314.
- ERRINGTON, P. L. 1930. The pellet analysis method of raptar food study. *Condor.*, **32** : 292-296.
- KHAJURIA, H. and GHOSAL, D. K. 1970. Small mammal eaten by Barn owl, *Tyto alba* (Scopoli). *Mammalia*, **34** : 718-720.
- KORSCHGEN, L. I. 1971. Procedures for food habits analysis : 233-250. In : *Wildlife management—techniques*. R. H. Giles. JR. (ed.). The Wildlife Society, Washington.
- MASON, G.F. 1943. *Animal tracks*. Marrow, New York.
- MCCLURE, H.E. 1945. Comparison of census methods for pheasants in Nebraska. *J. Wildl. Mgmt.*, **9** : 38-45.
- MURIE, O. J. 1954. *Field Guide to animal tracks*. Hoton Mifflin, Boston.
- STEWART, E. W. 1912. *Land of foot-prints*. Douldeday Page & Co., New York.
- WEBB, J. 1940. Identification of rodents and rabbits by their faecal pellets. *Trans. Kans. Acad. Sci.*, **43** : 479-481
- WILSON, K. A. 1938. Owl studies at An Arbor, Michigan. *Auk.*, **55** : 187-197.

#### DISCUSSION

- Q. Does the Zoological Survey have a reference collection of identified faecal pellets ? If so, does the collection include sample from small mammals such as rodents, insectivores and bats ?
- A. We have just now initiated to build up the collection of pellets and identify them, so that ultimately we can prepare a 'standard atlas' out of these material.

*Q. In the U. S. a method has been developed using difference in pH level to identify and distinguish between similar appearing faeces of various ungulates (e. g. deer Vs big horn sheep Vs prong horn antelope, etc.) Has any work of this nature been conducted in India ?*

A. No such method has been adopted to identify the droppings. It will be followed if it is found authentic in identifying them.

*Q. Are there any published sources of information on distinguishing faeces, pellets, pug marks of Indian mammals from other Asian countries ?*

A. There is no consolidated work on the subject.

*Q. What methods do you use for the preservation of faecal matters ?*

A. Usually dry them up and store in plastic bags. Details you may have in this proceedings after publication.

*Q. What method and technique you use to separate and identify the food materials found in faecal pellets ?*

A. Microscopic studies of the faecal pellets often led to identification of the prey species. Some of the food material can be identified if microscopical examination is performed.

*Q. How should faecal pellets, footprints, and pugmarks be accessioned into a museum collection ? Should they be catalogued along with the standard specimens (i.e. the skins and skeletal material), or should a separate record be kept for this material ?*

A. Separate records should be kept. Pellets may be preserved dry along with the collection.

## **CONSIDERATIONS FOR THE DEVELOPMENT, UTILISATION, AND CARE OF COLLECTIONS OF BACULA AND PHALLI**

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### **INTRODUCTION**

Studies of phallic morphology of mammals have been useful in differentiating species and assessing systematic relationships. Although these uses have been the primary reason for examining the structures, there are other applications, such as studies of histology or growth and development with age, that would be equally worth investigating. Traditionally, studies have included either the phallus (Arvy, 1978) or baculum alone (Anderson, 1960; Burt, 1960; Dearden, 1958; Hamilton, 1946; Harrison and Brownlow, 1978; Krutzsch, 1959, 1962; Long and Frank, 1968; Sinha, 1976; Thomas, 1915), or the baculum and external phallic morphology (Hooper, 1958, 1959, 1960, 1961, 1962; Hooper and Hart, 1962; Hooper and Musser, 1964; Lidicker, 1964; Williams, 1982; Williams *et al.*, 1980). Data collected for these studies usually involves general characteristics, bacular position, and phallic and/or bacular measurements. These data have proven to be an important aspect of mammalian systematic research and systematic collections (voucher and reference material), thus special considerations for the development, utilisation, and care of these materials are warranted.

The information that is available for the development, utilisation, and care of collections of bacula and phalli is scattered and collectively it does not cover the subject. The following will attempt to consolidate the available information on the subject, and include further comments based on the objectives and methods of mammal research collections (Williams *et al.*, 1977). The following discussion is divided into sections for development (methods of collecting and preserving phalli and bacula), utilisation (methods for identification and research purposes), and care (methods of permanent storage).

### **DEVELOPMENT**

Before studies of the phallus can be initiated, a basic knowledge of suitable fixatives is beneficial. Phallic tissues may be fixed for gross examination with 95% ethyl alcohol (Knudsen, 1966), 10% formalin



(1 part commercial 37-40% formalin and 9 parts water; Knudsen, 1966; Quay, 1974; Taylor, 1967), neutral buffered formalin (4 g acid or mono-basic sodium phosphate monohydrate ( $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$ ) and 6.5 g dibasic phosphate anhydrate ( $\text{NaH}_2\text{PO}_4$ ) dissolved into 1 litre 10% formalin; Quay 1974). or AFA (50 ml 95% ethyl alcohol, 10 ml commercial 37% formalin, 2 ml glacial acetic acid, and 40 ml distilled water; Russell, 1973). Van Gelder (1965) also recommends embalming fluid (1 part glycerin, 1 part 37% formalin, 1 part 90% ethyl alcohol, and 3 parts water) for fixing tissues. (Other fixatives and techniques are also available for studies of microstructure.) Most materials should remain in fixative for at least 7 to 10 days. Large phalli may require direct injection of fixative to prevent inner tissues from decomposing (improperly fixed tissues may decompose or incur damage to connective tissues during subsequent processing; Taylor, 1967). Comparing the fixatives, Russell (1973) comments that 95% ethyl alcohol is not a rapid-acting sterilizer and fixative, thus disintegration of material may occur. Although standard formalin is an ideal fixative it is usually acidic with a pH of 3.0 to 4.6 which can become more acidic with time. This acidity will cause decalcification of bones and deleterious chemical changes in other tissues (Quay, 1974; Van Gelder, 1965). The deleterious effects of standard formalin solutions can be minimised with buffers that will bring the pH closer to 7.0. AFA is a good fixative that has a bleaching effect on the specimen which facilitates easy examination of external characters and subsequent clearing and staining. Standard formalin solutions, embalming fluid and AFA should be thoroughly washed out of the tissues and replaced with 70% ethyl alcohol as soon as possible after fixation is completed. Russell (1973) suggests decantation for one hour, whereas Knudsen (1966) recommends soaking the material in distilled water for 24 hours. Buffered formalin may be treated the same way, but both buffered formalin and 70% ethyl alcohol are considered acceptable preservatives for permanent storage (Quay, 1974). The use of 70% ethyl alcohol is most often recommended (Levi, 1966; Quay, 1974; Taylor, 1967*a, b*).

Material obtained for studies of phallic morphology may be obtained from preserved specimens in research collections or from freshly collected specimens. In either case an awareness of this research resource is essential so that appropriate procedures for preservation are followed. Ideally, these procedures will become a standard part of specimen preparation so that there will always be the potential to use the material for research and identification even if it is not used by the initial investigator.

As a minimal effort, it is recommended that during the preparation of standard study skins of male specimens, the phallus be everted and left attached to the skin (Friley, 1947). Care should be taken to avoid inadvertently cutting or breaking the baculum (if present) or any of

the connecting skin. Those mammals that have a baculum include a few insectivores, all carnivores, most bats, most primates, most rodents (DeBlase and Martin, 1981), and pinnipeds. Once the phallus is properly removed with the skin, further attention is required to avoid sewing the phallus inside the specimen. The phallus is then dried with the rest of the skin and will always be associated with the specimen until it is removed for purposes of identification or research. When the phallus is removed from the skin it should be rehydrated by allowing it to soak in water for several hours. When the shape is restored it is then processed through stages of fixation, washing, and storage in a preservative.

Fluid-preserved specimens may be treated in a similar manner as study skins. If there are specific plans to study phallic morphology of a mammal group, it is recommended that the phallus of fluid-preserved specimens be everted prior to fixation. Efforts to evert the phallus after fixation are difficult and may cause the morphological features to be distorted or damaged. The phallus of fluid-preserved specimens should follow the same sequence of fixation, washing, and storage in a preservative (which may have been done while it was still attached to the specimen).

For active studies of phallic morphology it may be desirable to immediately evert and remove the phallus from the specimen, and then preserve it in a fixative. When a part of a specimen is removed, it is essential that it be properly labelled so that it can be reassociated with the rest of the specimen. One method is to simply place the label and excised specimen parts in a vial. If the availability of vials or fixative are limited, it may be desirable to tie the label to the base or proximal end of the phallus and then store phalli from several specimens in one container. For such situations crowding of specimens should be avoided.

Considering the methods discussed for developing a collection of phalli, the option of leaving the phallus attached to the specimen provides the easiest technique, allows association of all specimen parts, and still makes the material available for examination at a later date. However, the immediate removal and fixing of the phallus provides better preservation, thus making the material more suitable for detailed examination.

Collections of bacula may be developed in similar ways as phallic collections. The main consideration is removing extraneous tissue from the baculum. An awareness of cartilaginous and/or compound osseous parts of the baculum is necessary. For bacula that are large and completely osseous, standard methods of cleaning skeletal material (for example, dermestids) may be used. Friley (1947) and Hamilton (1946) discusses alternative methods, using maceration in potassium hydroxide,

for small specimens. For bacula that are partially cartilagenous and/or composed of multiple osseous parts it is best to try to keep these parts associated and in a natural condition. This may involve removal of tissues by potassium hydroxide maceration or careful dissection, and storage in a liquid preservative (to avoid alterations caused by desiccated cartilage).

Bacula are usually maintained in individual containers. If the baculum is dry and large enough, it should be labelled with permanent black ink (Van Gelder, 1965). Otherwise an appropriate label should be placed in the container with the baculum.

### UTILISATION

When utilising phalli and bacula for identification and research purposes it must be realised that within a species considerable variation of these anatomical structures is likely. This variation can be partially explained by natural nongeographical and geographical differences. Therefore, efforts are needed to minimise the amount of variation so that reliable assessments are possible. For instance, substantial differences are often attributed to age variation (Dearden, 1958; Harrison and Brownlow, 1978; Kennerly, 1958; Williams, 1982). To eliminate that variable for most comparative studies it is best to use only specimens of the same age, preferably adult individuals because it is safer to assume that the phallic and bacular development will be complete. Analysis of other forms of natural variation (for example, individual and geographical) are improved with adequate sample sizes from different geographical areas.

Although an understanding of natural variation is important for phallic studies, mechanical variation, or variation resulting from methodology, are perhaps of greater importance. Causes for mechanical variation can occur at almost any stage of the study. For instance, phalli improperly everted, removed, or preserved may appear different from those that have been properly treated; the softer tissues of the phallus can be easily damaged or deformed by crowded conditions in storage containers or desiccation during examination; methods used for documenting characters and taking measurements of each specimen can easily result in further inconsistencies. To minimise variation attributable to mechanical causes requires a concerted effort to standardise every detail of the entire procedure and use the same procedure for each specimen.

Often studies of the phallus have involved clearing and staining procedures. These procedures are primarily useful in determining the position and components of the baculum within the phallus. Thus, it is

often a necessary preliminary procedure for determining parameters for more detailed studies. The process of clearing and staining has been described by several authors (Davis and Gore, 1936; Friley, 1947; Hildebrand, 1968; Knudsen, 1966; Russell, 1973; Taylor, 1967*a,b*). Generally the procedure involves fixation and preservation (previously discussed), clearing, staining, destaining, and storing in glycerine. The following is a more detailed discussion of the steps not previously discussed. Before any part of the clearing and staining process is performed on any specimen, the external characters and dimensions of that specimen should be fully documented. The process is irreversible and it is possible that the procedures will alter the surface and dimensions of the phallus.

### *Clearing*

The clearing procedure is a maceration process that leaves the non-osseous tissues in a state approaching a gelatine consistency and transparent appearance. A 1% or 2% potassium hydroxide solution (1 or 2 g KOH and 100 ml H<sub>2</sub>O) is usually used (Friley, 1947; Hildebrand, 1968; Knudsen, 1966; Russell, 1973). Russel (1973) suggests using quantities of KOH solution equalling the volume of the sample. The amount of time that phallic samples will remain in the solution will vary according to size, with very small samples requiring about one hour, medium-sized samples requiring two to four hours, and the larger samples requiring eight to 12 hours (Friley, 1947). The time may be reduced by warming the solution. The initial clearing is completed when the baculum starts to become visible when held up to the light. There should not be much concern if samples are not totally transparent at the end of this step ; clearing will continue as long as the tissues are in KOH solutions.

Taylor (1967*a,b*) comments that the use of KOH for many materials, particularly those preserved for long periods of time, are not always satisfactory because excessive swelling may occur. He recommends the use of enzyme powders (for example, pancreatin, pancreatic protease, or trypsin) and sodium borate solution (30 parts saturated sodium borate solution and 70 parts distilled water) as an alternative. The phallus is placed in a volume of sodium borate solution that is 10 to 40 times greater than that of the sample, and then about 1 cc of enzyme powder is added to the solution. The sample is mascerated in the solution until it is almost clear. If the tissue has not been sufficiently cleared in 7 to 10 days, the solution should be replaced.

### *Staining*

The staining procedure is used for colouring the cartilagenous and osseous components of the baculum so that they will be apparent when

viewed through the cleared tissues. The staining of cartilagenous and osseous tissues is two separate procedures.

The staining of cartilagenous tissues may not be necessary if the baculum lacks cartilagenous parts or the investigator chooses to omit this part of the procedure because of difficulty of acquiring suitable results. However, if staining cartilagenous tissues is desirable, it should precede the staining of osseous tissues. Toluidine blue dye solution (100 ml 70% ethyl alcohol, 2 ml 0.5% hydrochloric acid, and 0.6-0.12 g dye) is recommended for staining cartilage (Burdi, 1965 ; Williams, 1941). Before use, the solution should stand for 24 hours and then be filtered. The amount of stain used should be about 20 times the volume of the specimen. The staining time required is about two days, but will vary according to the size of the specimen. The sample must be destained before staining of osseous tissue begins. Removal of the dark blue stain is accomplished by multiple washes in ethyl alcohol—20 hours in 35%, 28 hours in 50%, and 8 hours in 70% ethyl alcohol (Burdi, 1965).

To stain the osseous portions of the baculum, 1-8 drops of alizarin red S stain solution (saturate alizarin red S with 5 parts glacial acetic acid, 10 parts glycerin, and 60 parts water) is added to each 100 ml of KOH (Hildebrand, 1968; Russell, 1973); a deep purple colour will result. The time required for staining will vary from four to six hours depending on the size of the sample (Russell, 1973). Following the period for staining, the specimen is transferred to fresh KOH solution.

### *Destaining*

The destaining procedure involves removing the stain and saturating the tissues with glycerine. This is accomplished by methodically placing the sample in progressively increasing concentrations of glycerine for 24 hours each. The first solution is 20 parts glycerine, 3 parts 2% KOH, and 77 parts water. The second solution is 50 parts glycerine, 3 parts 2% KOH, and 47 parts water. The third solution consists of 75 parts glycerine and 25 parts water (Knudsen, 1966 Russell, 1973). Russell (1973) suggests maintaining the materials in the respective solutions for one to three weeks each. Finally the sample is placed in 100% glycerine.

### *Storing*

Glycerine (100%) is the liquid used for permanently storing cleared and stained tissues. It saturates the tissues and increases their firmness.

Clearing and staining of phalli are not absolutely necessary for studies of the phallus in fact, such procedures may not be desirable.

Not only is the procedure time-consuming but it can be a rather frustrating effort. The procedure may result in important and diagnostic epidermal structures being sloughed off (Hooper, 1958; Lidicker, 1968). Furthermore, it causes a softening of the tissues which (Hooper, 1958; Taylor, 1967) react to external pressures and surface desiccation by quickly changing shape; this, in turn, creates problems of taking accurate external measurements and identifying morphological features. Perhaps the greatest problem is that it may not be possible to get accurate measurements of the baculum even though it is clearly visible. Cleared tissues surrounding the baculum can cause distortion, thus making precise measurements questionable. To obtain accurate measurements of the baculum, it may be necessary to carefully dissect the baculum from the phallus. If this is done to a phallus that has been cleared and stained, the remaining tissue may become amorphous and virtually useless for further examination—thus, the only remaining part of the phallus is the baculum itself. Therefore, it is reiterated that the clearing and staining process is primarily useful for determining the position and components of the baculum.

As an alternative method to the clearing and staining procedure, it is recommended that more emphasis be placed on using only material that has received no more treatment than standard preservation. This will save time and it will allow the use of material that would have considerably fewer mechanical variables. Furthermore, the firmer tissue will normally retain epidermal structures and be less affected by external pressure and surface desiccation. The first step involves documenting in detail the external morphology and measurements (photographs can be useful for this purpose). Next, the baculum is dissected and the documentation is repeated. Although the dissection of the baculum destroys part of the softer tissues, it is possible to remove the baculum carefully and leave most of the remaining phallic parts intact and certainly suitable for further examination of epidermal structures and most external morphological features.

Hooper (1958) and Lidicker (1968) provide illustrations discussing terminology of phallic characters. The typical phallic and bacular measurements include length of distal tract, length of glans, length of protractile tip of glans, greatest diameter of glans, length of baculum, length of cartilage, height of baculum base, and width of baculum base (Hooper, 1958; Williams *et al.*, 1980; Williams, 1982). To establish the size relationship of the phallus to the body size, phallic dimensions are usually compared to a non-phallic character. Hooper (1958, 1959) used the length of the hindfoot. However, that dimension is subject to preparator's error and cannot be verified. Other studies (Williams *et al.*, 1980; Williams, 1982) have used condylobasal length. For bats, the forearm can serve the same purpose, as well as indicate the

age of the animal. For most other mammals it will probably be necessary to have the skull extracted so that a cranial measurement can be taken and the age of the specimen verified.

The ability to accurately measure parts of the external phallus and baculum is very important. For very large specimens, dial calipers accurate to 0.1 mm would be adequate. However, measurements are more difficult with smaller material. It is possible to produce enlargements of the structures with the use of a camera-lucida scope or with photographs. In either case, a millimetre scale should be included in every enlargement (it is very easy to alter measurements with the slightest focus adjustment). The actual magnification is determined by measuring one millimetre on the enlarged scale. Then it is a simple matter of taking measurements from the enlarged figure and dividing by the magnification to get the actual phallic or bacular dimensions. These measuring techniques allow easy verification, if necessary. It is also possible to take measurements of small materials with the careful use of a micrometer. (During periods of examination, it is advisable to work quickly and beware of active dimensional changes resulting from desiccation. These changes are particularly fast if the observation lights are placed too close to the specimen.)

The final results will depend on the quality control used throughout the examination and the amount of material examined. Data for one specimen will indicate basic characteristics and possible dimensions. With more specimens available, a more precise description is possible and statistical methods can be conducted.

#### CARE

The care of phallic material involves establishing a storage situation that will provide continuous protection and maintain the integrity of the specimen. The first aspect of providing perpetual care is adequately labelling each item so that it can be easily identified. Labelling should include at least the collection catalogue number and taxon. Other identifying numbers and collecting locality can also be used for the organisation and handling (removal and replacement) of the material. It is also very important that the remainder of the specimen be catalogued in the research collection and to be available as a voucher for subsequent verification of data, such as age and identification.

Phallic materials may be individually contained in a variety of ways. However, many of the methods are most applicable for small species of mammals. White (1951) suggests the use of microscope slide for dry bacula. Dry bacula may also be attached to insect pins (Friley,

1947). Vials are probably the most functional and versatile storage containers for most phallic materials, particularly if air-tight caps are used. Vials can accommodate dry and fluid-preserved material, and assortment of specimen sizes in equal-sized containers (larger specimens may require the use of long jars or boxes), and a flexible method of organisation. Vials that are used for fluid-preserved material should not be placed in a position that would make leakage possible ; for prevention of leakage, as well as evaporation, it may be necessary to seal the cap with plastic tape or melted wax (Van Gelder, 1965). For vials containing either dry or fluid material it is possible to provide additional protection during storage, and organisation capabilities, with the use of Styrofoam (Hoffmeister, 1973) or wood panels that have appropriate sized holes made to hold the vials.

For most situations, fluid-preserved material is permanently stored in either 100% glycerine or 70% ethyl alcohol depending on previous treatment. Material that has been cleared and stained should be stored in glycerine. The use of metal (labels or vial caps) should be avoided because it will cause colouring of glycerine. It is recommended that thymol crystals be added to the glycerine to prevent mould growth (Taylor, 1967*a, b*). Any material that has not been cleared should be permanently stored in 70% alcohol. For material stored in either glycerine or alcohol, all efforts should be made to prevent loss of liquid and desiccation. If any phallic material is allowed to dry after fixation it is unlikely that the original shape will ever be obtained. Levi (1966) discusses possible methods of reconditioning material that has been dried.

In research collections of Recent mammals phallic materials may be stored and maintained in different manners. Dry bacula may be placed in separate containers, such as gelatin capsules and stored with the osteological materials of the specimen. Likewise, fluid-preserved phallic material may be placed in appropriate locations with the alcoholic collection. However, it is not uncommon to maintain a special collection consisting of only phallic and bacular material. In such situations the material can conveniently be stored in a phylogenetic arrangement to subfamily and then alphabetically to species or subspecies. Further criteria may be used for organisation, but for situations that do not involve large series of specimens a simple sequential arrangement by collection catalogue number should be adequate.

#### CONCLUSION

Studies of the phallus and/or baculum offer an easy method of obtaining valuable information from specimens acquired for the research collection. There is still considerable potential and need for quality research in this field.



When studies are being initiated, it is important to be aware of natural and mechanical factors that may contribute to variation. To minimise these factors, efforts should be made to use adult individuals as much as possible, and to substantiate the available data with appropriate sample sizes. Furthermore, it is very important to refine and standardise the methodology of the entire study. For the sake of preserving the phalli and maintaining material for future reference, it is recommended (except for determination of the position and components of the baculum) that clearing and staining procedures be replaced with simple dissection.

It is not intended that this paper serve as the final word on the subject. Anyone working with phallic material may discover that the precise techniques developed for a particular study may not work as well for another group of mammals or set of conditions. There are various other applications that are worth further consideration, such as the use of X-ray (Hildebrand, 1968), freeze-drying (Hower, 1964, 1967; Meryman, 1960, 1961), and possibly others (Hildebrand, 1968). It is hoped that the available information has been consolidated, and that this paper will serve as a useful reference for future work.

#### SUMMARY

Phallic morphology of mammals can be applied to identification of species and various research projects, such as differentiation of species, assessing systematic relationships, histology, and growth and development. Because of the research potential and obligation of mammal collections to maintain voucher and reference material special considerations are warranted for the development, utilisation, and care of collections of bacula and phalli.

The development of a phallic and bacular collection begins with the accumulation and preservation of such materials. The collection of these materials should be at least a standardised operation of specimen preparation. If studies involving the phallus are actively being conducted, then other methods are available to improve the quality of the material.

When utilising phallic material for research or identification purposes, it is important to be aware of natural and mechanical causes of variation. Because of age variation, it is best to use adult specimens for most comparative studies. Younger individuals are most useful for studies of variation with age or growth and development. A major cause of mechanical variation in these studies is the process of clearing and staining. This process is most useful in determining the position and

components of the baculum. Once this is done with representative specimens, it is recommended that the description and measurements be taken from material that has only been preserved. To obtain data from the baculum it is recommended that it be carefully dissected from the phallus so that both will be available for future examination. Examination procedures require detailed descriptions and accurate measurements.

The care of phallic and bacular material requires adequate labelling of each item to promote organisation and ease in handling. These items may be stored in glass vials with air-tight, non-metallic caps. Fluid-preserved material will be stored in 70% ethyl alcohol or, if cleared and stained, in 100% glycerine. Bacula may also be stored with microscope slides, insect pins, or in boxes. Both fluid-preserved and dry materials may be stored in the research collection by various methods.

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#### REFERENCES

- ANDERSON, S. 1960. The baculum in microtine rodents. *Univ. Kans. Publs. Mus. Nat. Hist.*, **12** 181-216.
- ARVY, L. 1978. Le penis de Cataces. *Mammalia*, **42** 491-509.
- BURDI, A. R. 1965. Toluidine blue-alizarin red S staining of cartilage and bone in whole-mount skeletons. *Stain Technol.*, **40** : 45-48.
- BURT, W. H. 1960. Bacula of North American mammals. *Misc. Publs. Mus. Zool., Univ. Mich.*, **113** : 1-76+25 pl.
- DAVIS, D. D. and GORE, U. R. 1936. Clearing and staining skeletons of small vertebrates, *Tech. Ser. Field Mus. Nat. Hist.*, **4** : 1-15.
- DEARDEN, L. C. 1958. The baculum in *Lagurus* and related microtines. *J. Mammal.*, **39** : 541-553.
- DEBLASE, A. F. and MARTIN, R. E. 1981. *A manual of mammalogy with keys to families of the World* : xii+1-436. W C. Brown Co. Publ., Dubuque, Iowa.

- FRILEY, C. E., Jr. 1947. Preparation and preservation of the baculum of mammals. *J. Mammal.*, **28** : 395-397.
- HAMILTON, W. J., Jr. 1946. A study of the baculum in some North American microtinae. *J. Mammal.*, **27** : 378-387.
- HARRISON, D. L. and BROWNLOW, I. P. 1978. A comparative study of the baculum in bats of the genus *Scotophilus* (Chiroptera : Vespertilionidae). *Mammalia*, **42** : 123-130.
- HILDEBRAND, M. 1968. *Anatomical preparations* : viii+1-100. Univ. California Press, Berkeley.
- HOFFMEISTER, D. F. 1973. A suggested method of shipping skulls in vials. *J. Mammal.*, **54** : 293-294.
- HOOPER, E. T. 1958. The male phallus in mice of the genus *Peromyscus*. *Misc. Publs. Mus. Zool., Univ. Michigan*, **105** : 1-24+14 pl.
- HOOPER, E. T. 1959. The glans penis in five genera of cricetid rodents. *Occ. Pap. Mus. Zool., Univ. Mich.*, **613** : 1-11+5 pl.
- HOOPER, E. T. 1960. The glans penis in *Neotoma* (Rodentia) and allied genera. *Occ. Pap. Mus. Zool., Univ. Mich.*, **618** : 1-21+11 pl.
- HOOPER, E. T. 1961. The glans penis in *Proechimys* and other caviomorph rodents. *Occ. Pap. Mus. Zool., Univ. Mich.*, **623** : 1-18.
- HOOPER, E. T. 1962. The glans penis in *Sigmodon*, *Sigmomys* and *Reithrodon* (Rodentia, Cricetinae). *Occ. Pap. Mus. Zool., Univ. Mich.*, **625** : 1-11.
- HOOPER, E. T. and HART, B. S. 1962. A synopsis of Recent North American microtine rodents. *Misc. Publs. Mus. Zool., Univ. Mich.*, **120** : 1-68.
- HOOPER, E. T. and MUSSER, G. G. 1964. The glans penis in Neotropical cricetines (family Muridae) with comments on classification of muroid rodents. *Misc. Publs. Mus. Zool., Univ. Mich.*, **123** : 1-57.
- HOWER, R. O. 1964. Freeze-drying biological specimens. *Tech. Suppl. Mus. News*, **1** : 1-8.
- HOWER, R. O. 1967. The freeze-dry preparation of biological specimens. *Proc. U. S. Natn. Mus.*, **119** : (3549) : 1-24.

- KENNERLY, T. E., Jr. 1958. The baculum in the pocket gopher. *J. Mammal.*, **39** : 445-446.
- KNUDSEN, J. W. 1966. *Biological techniques* : xi+1-525. Harper and Row Publ., New York.
- KRUTZSCH, P. H. 1959. Variation in the Os penis of tropical fruit bats. *J. Mammal.*, **40** : 387-392.
- KRUTZSCH, P. H. 1962. Additional data on the Os penis of Megachiroptera. *J. Mammal.*, **43** : 34-42.
- LEVI, H. W. 1966. The care of alcoholic collections of small invertebrates. *Syst. Zool.*, **15** : 183-188.
- LIDICKER, W. Z., Jr. 1968. A phylogeny of New Guinea rodent genera based on phallic morphology. *J. Mammal.*, **49** : 609-643.
- LONG, C. A. and FRANK, T. 1968. Morphometric variation and function in the baculum, with comments on correlation of parts. *J. Mammal.*, **49** : 32-43.
- MERYMAN, H. T. 1960. The preparation of biological museum specimens by freeze-drying. *Curator*, **3** : 5-19.
- MERYMAN, H. T. 1961. The preparation of biological museum specimens by freeze-drying II. Instrumentation. *Curator*, **4** : 153-174.
- QUAY, W. B. 1974. Bird and mammal specimens in fluid—objectives and methods. *Curator*, **17** : 91-104.
- RUSSELL, E. L. 1973. Improved methods for staining bones of small fetuses and vertebrates in alizarin red S. *Bioscience*, **23** : 366-367.
- SINHA, Y. P. 1976. Bacula of Rajasthan bats. *Mammalia*, **40** : 97-103.
- TAYLOR, W. R. 1967a. An enzyme method of clearing and staining small vertebrates. *Proc. U. S. Natn. Mus.*, **122** (3596) : 1-17.
- TAYLOR, W. R. 1967b. Outline of a method of clearing tissues with pancreatic enzymes and staining bones of small vertebrates. *Turtox News*, **45** : 308-309.
- THOMAS, O. 1915. The penis bone as a guide to classification of certain squirrels. *Ann. Mag. Nat. Hist., Ser. (8)* **15** : 383-387.

- VAN GELDER, R. G. 1965. "Another man's poison" *Curator*, **8** : 55-71
- WHITE, J. A. 1951. A practical method for mounting the bacula of small mammals. *J. Mammal.*, **32** : 125.
- WILLIAMS, S. L. 1982. Phalli of recent genera and species of the family Geomyidae (Mammalia : Rodentia). *Bull. Carnegie Mus. Nat. Hist.*, **20** 1-62.
- WILLIAMS, S. L., HAFNER, J. C. and DOLAN, P. G. 1980. Glans penis and bacula of five species of *Apodemus* (Rodentia : Muridae) from Croatia, Yugoslavia. *Mammalia*, **44** : 245-258.
- WILLIAMS, S. L., LAUBACH, R. and GENOWAYS, H. H. 1977. A guide to the management of Recent mammal collections. *Spec. Publ., Carnegie Mus. Nat. Hist.*, **4** : 1-105.
- WILLIAMS, T. W., JR. 1941 Alizarin red S and toluidine blue for differentiating adult or embryonic bone and cartilage. *Stain Technol.*, **16** : 23-25.

#### DISCUSSION

- Q. *Can the larvae of dermestids be used for the extraction of baculum ?*
- A. Removal of the baculum may be done by careful dissection, maceration with potassium hydroxide, or with small dermestid larvae. The most suitable method used will depend on the species of mammal involved. For those species of mammals having multiple osseous or complex cartilaginous structures the use of dermestid larvae would probably not be desirable.

## **NON-PEST MANAGEMENT PROBLEMS IN MAMMAL COLLECTIONS IN TROPICAL ENVIRONMENT**

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### **INTRODUCTION**

The importance and value of reserve collections and museum exhibits of mammal, like any other zoological material, are understood by everybody, and the necessity of its maintenance is beyond any controversy. In broad outline, management of mammal collection includes various aspects such as collection preservation, storage, damage by pests, and non-pest related problems. Effective care and management of all these factors are the basic duty of a scientific institution or a museum.

An institution or a museum, whether in a temperate, tropical or in an arid country, faces almost the same basic problems in maintaining a mammal collection. Slow but gradual deterioration of a stuffed skin, fluid preserved material or skeletal material, takes place from handling of the collection either for storage or for study purposes, accession, etc. The major injury, however, is due to high percentage of humidity, temperature, light, and pollution. These factors have their worst possible effect in maintenance of mammal collections, particularly in tropical climates. Grease free specimens, proper storage, use of correct preservative, prevention against damage and loss, updating of scientific names, etc., are important factors in maintenance of mammal collections. However, many of these problems can be handled satisfactorily with the execution of a number of preventive measures and periodic supervision.

While different management aspects have been discussed during various sessions of this workshop, in this paper only the non-pest maintenance problems, together with treatments to be undertaken, are discussed. In literature, however, a number of references are available on various aspects of preservation, storage and maintenance of collections. Some of them to mention are Anon (1962), Colbert (1961), Feller (1964), Force (1975), Funk and Sherefy (1975), Giles (1966), Hall (1962), Jackson (1926), Morrill (1962), Palmer (1974), Stelow (1966*a, b*), Wagsstaffe and Fidler (1955) and Zweifel (1966). An account of the collection, preparation, storage, management, etc., of mammal collection has been given by Williams *et al.* (1977).

## ENVIRONMENT

*Temperature and moisture*

The effect of temperature and moisture on collections is of great concern as regards their maintenance and care. Temperature is, however, of primary importance, for it regulates the moisture content at a particular place. It has great effect in tropical countries. In tropical plain lands, during summer, temperature vary between 40 and 50°C, and in winter, the barometer may fall down at places as low as 0°C, thus bringing high fluctuation in atmospheric moisture contents. Temperature and moisture may fluctuate daily, weekly, as also subject to sudden changes, which effect the indoor weather of the laboratory, accordingly. The collection of skins, fluid-preserved specimens, and osteological material, if remain uncared for, absorb water vapour from the atmosphere. The collection absorbs water vapour from the moisture sensitive wooden furniture and card board boxes in which it is stored, also from wrapping papers and packing cotton and skull bags made of cloth, etc. When the humidity is high, skins and bones absorb more moisture and expand, when it is below optimum they shrink. Rapid fluctuation in moisture content is more damaging to older material, resulting in cracking and warping of specimens.

An optimum moisture and temperature control in storage areas, exhibition halls in the museums and in the laboratory are the best solution to retain the constant geometry of the collection. For this purpose various measures are to be taken to reduce humidity in general storage conditions. In this connection, the first stép generally taken is to store the specimens inside closed cabinets, show cases, habitat-cases and boxes, which are somewhat impervious to moisture, thus controlling the constant exposure of the collection to higher relative humidity. Use of dehydrated silica gel has also been suggested for eliminating moisture in storage places. There is one advantage in using it, the gel can be dehydrated by heating in oven for further use. Air conditioning the whole laboratory or the museum building is, however, considered to be the best means of temperature and moisture control. In case of inability to control these factors in the whole building due to lack of finances, humidifiers and dehumidifiers may be installed in storage rooms. To make the conditioning fully effective, windows should be tightly sealed and the doorways installed with automatically-closing doors.

It is suggested that relative humidity within a range of 45 to 65% and temperature from 18 to 23°C are most suitable for the maintenance of collections (Stolow, 1966a). Hence, this optimum RH and temperature should be maintained inside the laboratory as far as possible.

### *Light*

Light is a form of energy, which has the ability to emit heat for photochemical changes in animal skins, thus fading the pigments of the specimens. The colour changes in the study skins can be visually noticed after its long exposure to light and can also be measured with a calorimeter. The fading or yellowing ('foxing') of the study skins and fluid-preserved specimens with which many of us are acquainted, is due to the effect of intensive exposure to light.

All types of lights like sunlight or light from electric bulbs and fluorescent lamps have varying degrees of effect on the preserved specimens. The intensity of day light fluctuates depending on the angle of the sun, season, the conditions of the atmosphere, and the degree of scattering from clouds or dust particles, and effects the colouring matter of the collection accordingly. In tropical countries, perhaps the zenith blue skylight causes greater damage to the skins. It is proved that incandescent light is less damaging to skins as compared to zenith blue skylight and fluorescent lights radiating ultraviolet rays (Stolow, 1966b). However, the deteriorating effect of light is considerably speeded up by external factors like higher temperature, higher humidity, and the pressure of oxygen. It is recorded that for every ten degree rise in temperature the rate of photochemical change on the collection is doubled.

In normal practice, closed dark rooms which is lighted only during handling of specimens, is preferred for avoiding the effects of light on mammal collections. Closed almirahs, shelves, and boxes also preserve the collection from the deteriorating effect of light. In institutions, due to space shortage, where a common hall is used for the sitting accommodation of scientific staff and for keeping the collection cabinets, arrangement should be made to keep the storage area dark as far as practicable by putting off the lights, and by providing opaque curtains to windows of the room. The shelves containing the specimens in preservative should also be shielded from light by covering those with opaque plastic sheets or otherwise. For protection against the ultraviolet radiation effect of fluorescent lights, plastic shields containing UV absorbent shreds, should be used. However, incandescent light is comparatively better in collection areas.

### *Pollution*

Dust is one of the major problems in the maintenance of collection in a tropical environment. Many of us who handle collections, storage almirahs, shelves, etc. are aware of the noticeable quantity of dirt, which attract moisture profusely, causing remarkable damage to skins and osteological material. The air, besides its chief constituents like nitrogen,



oxygen and a few rare gases, also contains carbon dioxide, sulphur dioxide, and pollutants like dust, microorganisms, etc. The last two items, i.e., dust and microorganisms, with atmospheric moisture, produce mould, causing abrasion to skin and fragility to skeletal material. The growth of the pollutant mould is also facilitated by conducive amount of relative humidity and temperature. The 'foxing' of skins to some extent is also believed to be due to mould-formations, rich with microorganisms. Sulphur dioxide emitted by industries is an important pollutant, for it is easily converted into sulphate-compounds that blister and itch the surface of skins. The soot present in the atmosphere may also contain absorbed sulphur compounds, that act as pollutants.



Fig. 1.—A few uncared bovid skulls in the collection.

To prevent the collection from various effects of pollution is a difficult job, but by checking the flow of pollutants and moisture to the collection, one may minimise the possibility of mould growth. Thus, collection almirahs, shelves and boxes with close-fitting drawers and lids, museum exhibits in showcases with sealed glass walls, storage rooms and exhibition halls with caulking windows and weatherstripping doors reduce the entry of dirt in the collection. Closed boxes and trunks save skeletal material from mould growth. Uncared for skeletal material

like big skulls (Fig. 1) and long limb bones lying here and there in collection storage due to space problems can be protected from dust by wrapping them in polythene sheets. To remove the mould the specimens should be periodically brushed. Over and above, an efficient and properly designed air filtering system in the storage room and museum hall, along with regulated relative humidity and temperature, is the best way to eliminate pollution problems in collection.

## OTHER FACTORS

### *Fat*

The presence of fat on the skin, spoils the material ultimately. Fats on the skin oozes out in course of time and damage the fibres in it by way of oxidation. The fat present in the osteological material, when exuded, collects dirt and attracts pests, besides giving offensive smell.

The skins may be saved from the effect of fat by degreasing the skin by dipping them in fat solvents like carbon tetrachloride, white petrol etc., till the excess of fat is removed and then drying it. The use of petrol requires special attention against fire, for it is highly inflammable. Other chemicals may also be used, but are costly. For degreasing the osteological material the method usually applied is to wash them with hot water and detergents, then rewash it with water followed by bleaching with 4% hydrogen peroxide. Finally it is dried.

### *Fluid-preserved collection*

Formalin solution (10%) is a good preservative of mammal specimens in the field, but permanent storage in this solution is a poor choice, for specimens in formalin solution become dark, obliterating the colour pattern and decalcifies the bones. It is also highly corrosive to metal, jar tops and becomes acidic after sometime. Therefore, 70-75% ethyl alcohol is widely used for wet preservation of mammals. Whatever preservative is used, its strength should be checked from time to time, since there is possibility of its dilution from body fluid of the specimen and from atmospheric moisture.

For Storage, containers (glass jars) of various shapes and sizes with several kinds of closures are in common use. The best jars are the 'Killner Jars' with a rubber washer and a glass lid, held firmly by a cap. Killner jars of different sizes are not readily available in the market and they are costly even. Wide-mouth glass jars of different shape and sizes (Fig. 2 a) with glass tops are hence, used for the alcohol-preserved specimens. However, which ever jar is used, the lid of it must

be sealed with petroleum jelly to prevent evaporation of the preservative. It is also desired that the volume of preservative should be at least twice that of the specimens (Zweifel, 1966).

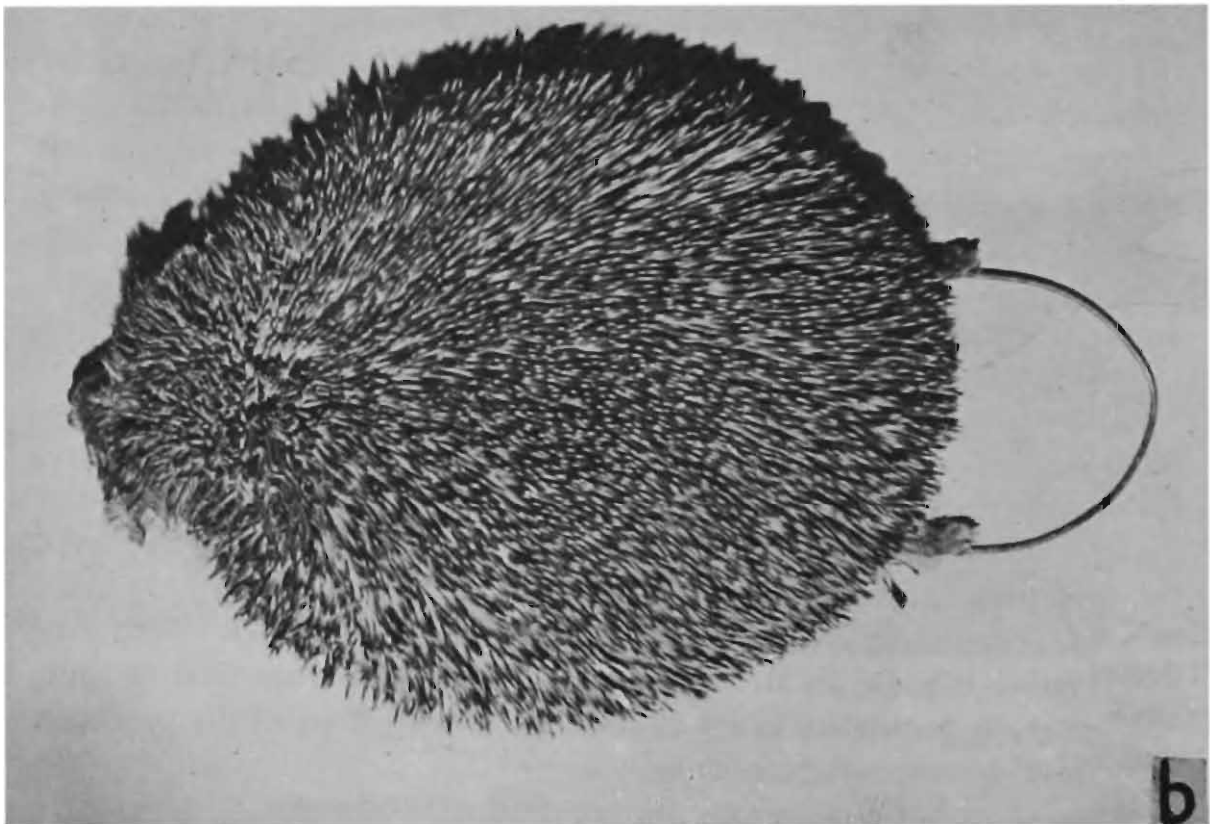


Fig. 2.—*a*. Some wide mouth glass jars of different sizes used for storing wet mammal collection ; *b*. Photograph showing the wire handle provided to a hedgehog skin for easy handling.

Dried up alcohol-preserved specimens sometimes need to be rehydrated. In general practice, it is done by treating the material through

a graded series of alcohols to water. Others, such as aerosol solution or 1 % trisodium phosphate solution are also useful (Williams, *et al.*, 1977).

Skulls are often taken out from fluid preserved specimens for study purposes. The gaps thus formed are filled in with cotton, keeping the shape of the head, and stitched to prevent subsequent tearing of the head.

### *Handling of material*

Much of the damage that our collection receive is as a result of handling. The way in which specimens are stored can reduce the amount of bad handling they receive. Care is necessary to avoid overcrowding of specimens in the containers. To avoid injuries to specimens, the best idea should be to keep dry collection in a single layer so that the material can be easily seen or handled. For lack of space, material can also be stored in shelves in more than one layers, with acid free tissue papers between the layers, so that the specimens are not up to the point of crushing and wrinkling due to over weight (Fig. 3). In case of wet-specimens, allowing a single specimen in one jar is the safest way of maintaining them. Often there are number of old fragile specimens in the collection. Special handling instruction for them should be marked on the outside of the container in which it is kept. Another way to reduce the potential damage to body parts as tail in hare, squirrel, etc., or for easy handling of specimens having spines on the body, like hedgehog, porcupine, etc., is to provide wire handle to them during preparation of the study skins (Fig. 2 *b*). Many specimens, such as a large skull, a flat skin or a fragile specimen may benefit from a frame, and damage to its parts can be avoided by putting supports to them.

### *Repair of material*

Pieces of skins, appendages, teeth, etc., sometimes get detached in handling. All such things should be reattached with some impervious adhesive (Duco, Stickfast, etc.) or by stitching.

### *Flat Skins*

Tanned skins in the collection are subject to drying and tearing. Such skins are to be treated with preparation of sulphonated neats foot oil which should be applied on the flesh side of the hide (Williams *et al.*, 1977).

### *Wrapping paper*

At times some material, such as very old and poorly preserved specimens, needs to be wrapped in papers. Attention should be given

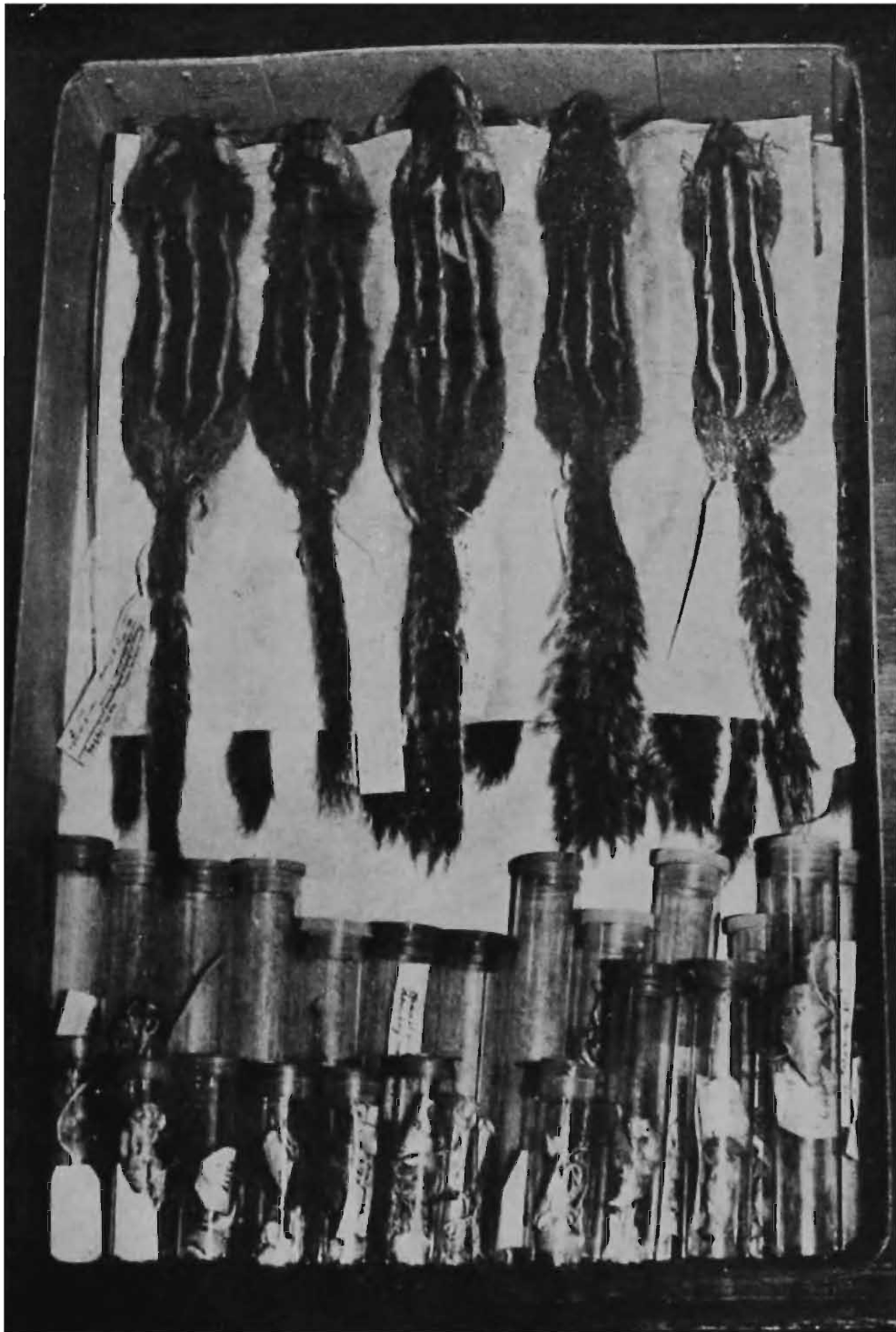


Fig. 3.—Storage of skins and skulls in the collection almirah.

that the tissue papers are acid free, otherwise the specimens will become brittle due to acidic reaction.

Many problems on care of specimens can be handled even with limited supervisory staff and fund at the disposal of an institution. However in addition to the problems mentioned above, adequate registration and cataloguing of material, compilation of species index-card with appropriate data, are also considered to be factors in maintenance

of the collection. The second important factor is to protect the collection from fire, earthquake, etc. Suitable fire fighting arrangements should be made so that in case of fire it may be extinguished without much damage to the collection. Spirit collections should be housed in special buildings like one maintained by the ZSI. Further, to cover losses due to natural calamities, the collection and the building in which it is housed should be insured as far as possible. Though it will not directly save the collection, but in turn will partly meet the huge expenditure incurred in building up that collection.

#### SUMMARY

The importance of the collection of mammals is an established fact. Their maintenance is nevertheless equally important, especially when many tropical species are becoming threatened at a fast rate for various reasons. With the knowledge of some fundamentals about collection care, the maintenance of these material, even for a small institute with its limited financial resources and staff strength, is not difficult. As it is considered here, moisture, temperature, light, pollution, space problem, handling of specimens, etc., are some of the important factors related to the non-pest management and maintenance of our tropical collection. Within the limited scope of this paper, these basic points, together with a few others, have been discussed.

#### ACKNOWLEDGEMENTS

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#### REFERENCES

- ANONYMOUS 1962. Solving storage problems. *Museum News*, **41(4)** : 24-29.
- COLBERT, E. H. 1961. Inexpensive racks for the storage of large specimens. *Curator*, **4** : 368-370.
- FELLER, R. L. 1964. Control of deterioration effects of light upon museum objects. *Museum*, **17** : 57-58.
- FORCE, R. W. 1975. Museum collections—access, use and control. *Curator*, **18** : 249-255.

- FUNK, F. and SHEREFY, K. 1975. Uses in Edulan U in museum preparation and conservation of zoological material. *Curator*, **18** : 68-76.
- GILES, C. H. 1966. The fading of colouring matters. *Curator*, **9** : 95-102.
- HALL, E. R. 1962. Collecting and preparing study specimens of vertebrates. *Univ. Kansas Mus. nat. Hist., Misc. Publ.*, **30** : 1-46.
- JACKSON, H. H. T. 1926. The care of museum specimens of recent mammals. *J. Mammal.*, **7** : 113-118.
- MORRILL, C. R. 1962. Dust proofing exhibits by air pressure. *Curator*, **5** : 53-54.
- PALMER, W. M. 1974. Inexpensive jars for museum specimens. *Curator*, **17** : 321-324.
- STOLOW, N. 1966a. The action of environment on museum objects. Part 1. Humidity, temperature, atmospheric pollution. *Curator*, **9** : 175-185.
- STOLOW, N. 1966b. The action of environment on museum objects. part 2. Light. *Curator*, **9** : 298-306.
- WAGSTAFFE, R. and FIDLER, J. M. 1955. *The preservation of natural history specimens*. Philosophical Library, Inc., New York, XIII+205 pp.
- WILLIAMS, S., LAUBACH, R. AND GENOWAYS, H. H. 1977. A guide to the management of recent mammal collections. *Spec. Publ., Carnegie Mus. Nat. Hist.*, **4** : 1-104.
- ZWEIFEL, R. G. 1966. Guide lines for the care of a herpetological collection. *Curator*, **9** : 24-35.

#### DISCUSSION

- Q. *Is fluctuation of temperature alone responsible for the damage of dry skins as shown by slides ?*
- A. I have not shown any slide related to the effect of temperature on skin. The slides shown were on the spectral quality of light that increases with the rise of temperature and effect of humidity on various objects. However, it is an established fact that temperature has deteriorating effect on skin.

- Q. In your paper you have mentioned that acid-free tissue paper should be used to wrap specimens. The paper termed “acid-free” in U. S. is actually alkaline-buffered to a pH of 8.5 or higher and is not recommended for use since it may damage the protein based specimens. Is the acid-free paper, recommended by you, of the same type ?*
- A. Presently we are not using the acid free paper, but it is a proposal. The point mentioned by you is worth considering.





## **PEST CONTROL MANAGEMENT FOR MAMMAL COLLECTIONS**

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### **INTRODUCTION**

The over 700 mammal research collections throughout the World (Choate and Genoways, 1975; Genoways and Schlitter, 1981, 1985) hold almost 5 million scientific and exhibit specimens. Because considerable amounts of time, effort, and expense are expended in obtaining and maintaining such materials, many methods have been devised to insure the safety and value of the specimens. Museums have traditionally used storage cases to protect their specimens from damage caused by light, dust, moisture, physical abuse, and pests (Williams *et al.*, 1977). Although such cases afford satisfactory protection against most damaging agents, they have only limited value against pests, particularly insect pests. Insect pests can easily enter storage areas during normal staff activity. They can be introduced into the storage cases with incoming loans or field collections or they can enter the case when it is open for use. Insects can exist in collections in various life stages and are capable of totally destroying research specimens.

It is the responsibility of the curator to protect the collection against attack by insect pests. However, this is a concern that may in many ways be beyond his area of expertise. It requires him to be able to identify the insect causing the problem and to know enough of the life history of the species to be able to combat it. He must have the latest information on insecticides so that he can use the most effective one but still be able to safeguard the health of his staff and the long-term preservation of the collection.

In the following sections, we have tried to give a brief description of common insect pests known to attack mammal collections. We have outlined procedures for an overall pest management plan and for the safe application of insecticides. Finally, we have compiled the latest information on insecticides that is available for use against pests. It must be emphasised that this is the information that was available as of 1 January

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1984. New information will become available in the future and it is the obligation of the curator to keep himself informed.

#### INSECT PESTS

A number of groups of insects are recognised as pests of museum collections. However, most information available concerning these pests is drawn from research studies done in temperate parts of the World. Many of these pest species are cosmopolitan and occur in both temperate and tropical regions. Some, in fact, are naturally occurring tropical species which have been carried, during historical times, to the temperate countries and then have become indoor pests in these new homes. Such species will without a doubt establish themselves as pests in museum collections as collections are established in these tropical countries. In cosmopolitan families with pest species occurring only in the temperate regions, relatives confined to tropical regions may prove to be equally serious pests of museum collections. Studies focusing on the identification and detailing of life histories of pests in museum collections in tropical countries are lacking. There is a critical need for such studies and persons maintaining museum collections in tropical countries can participate in this type of research by collecting data during their normal curatorial activities.

The primary insect pests of museum collections are discussed in the following accounts. General information on damages and life histories are given as it relates to pests of actual mammal specimens or associated items such as written records or books. Not covered are some pests, such as termites, which may destroy the actual buildings housing the collections or, in some instances of severe infestations, wooden specimen storage cases.

##### *Family Dermestidae*

Of the beetles that commonly infest museum collections, the family Dermestidae, usually referred to as dermestids or carpet beetles, are the worst enemy. The species in this large family of beetles can be divided into three groups based on their feeding habits (Mallis, 1964) : (1) species which are obligatory carnivores, maintaining themselves on animal matter or material containing animal protein ; (2) species which normally live on animal matter but can reproduce on a diet of vegetable matter only ; and (3) species which are obligatory vegetarians. The majority of species belong to the first group. A number of species in the family have become commensal in their habits, but any local species in any country can become a pest in museum collections. Those species which are generally recognised as pests in museum collections (Edwards *et al.*, 1981) are the Furniture Carpet Beetle, *Anthrenus flavipes* Le Conte;

Varied Carpet Beetle, *Anthrenus verbasci* (Linnaeus); Black Carpet Beetle, *Attagenus megastoma* (Fabricius); Larder Beetle, *Dermestes lardarius* Linnaeus; Carpet Beetle, *Reesa vespula* (Milliron); Odd Beetle, *Thylodrias contractus* Motschulsky; and the Cabinet Beetles, *Trogoderma inclusum* Le Conte, *T. ornatum* (Say), *T. sternale* Jayne, and *T. variabile* Ballion. The larval stage is the primary damaging stage in the dermestids (Fig. 1). Targeted items found in a mammal collection are skins, tanned hides and leather, wool and fur, hair, and horn (Figs. 2 and 3). Other items which may be attacked are materials from mammal nests such as hair or feathers and samples of food items such as seeds.

Adults of dermestids range in length from 1.8 mm in the Furniture Carpet Beetle and Varied Carpet Beetle, up to 7.5 mm in the Larder Beetle, a long and slender species. Generally, adults are about 3-4 mm for most species. Larvae range in length from 2 mm up to the longest instars of the Black Carpet Beetle and Larder Beetle at 8-13 mm. Eggs may be deposited on the targeted food source, but also may be secreted in the storage area (Mallis, 1964). The Larder Beetle commonly deposits

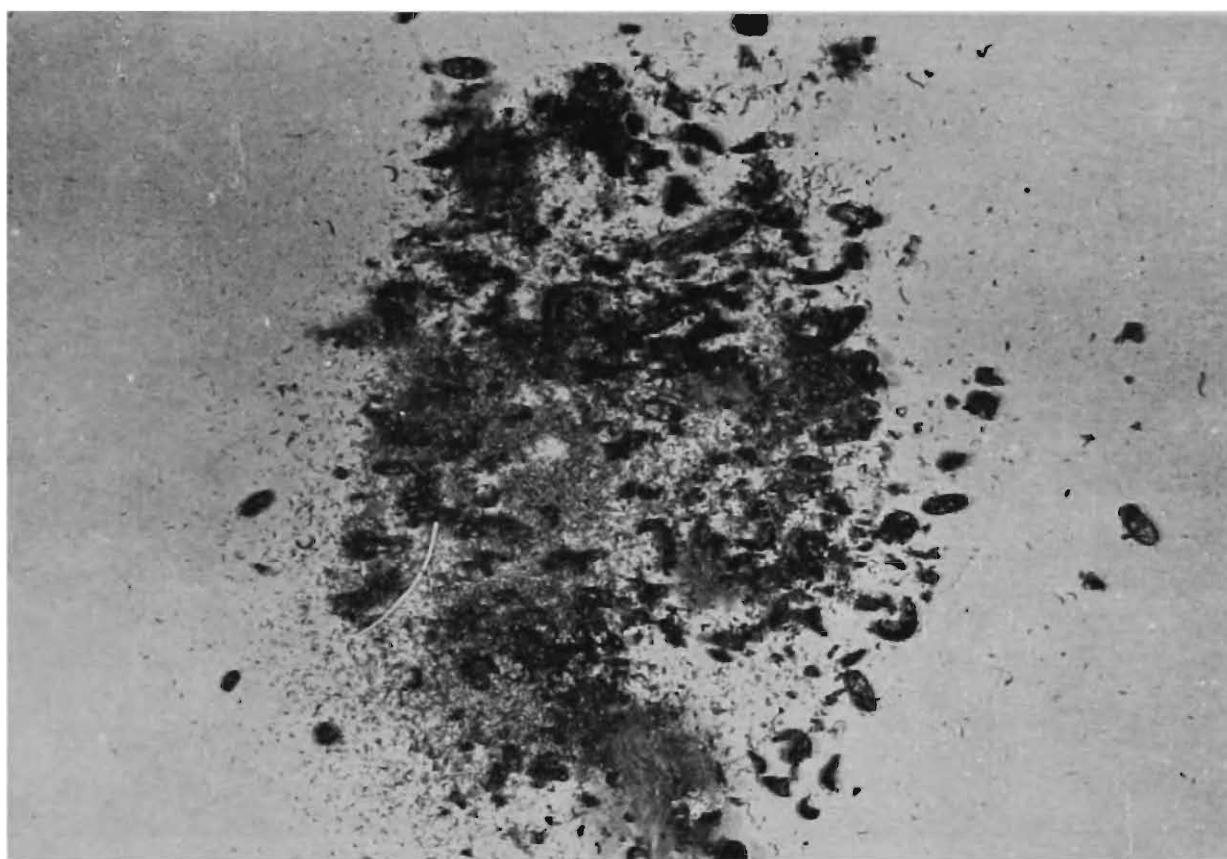


Fig. 1.—Debris from dermestid beetles including excrement, larval skins, dead adult beetles, and hair from a mammal specimen.

its eggs in crevices and cracks adjacent to the food source, while the Black Carpet Beetle may deposit its eggs in the lint around the baseboards of walls and in the ducts of central heating systems (Mallis, 1964).

The life cycle of the Black Carpet Beetle is typical for the family, although variation is present as a result of conditions of temperature, food, and humidity (Mallis, 1964). The eggs, very fragile in nature, hatch after 6 to 11 days in normal conditions. The larva, covered with stiff hairs, is long and narrow, up to 8 mm in length. Although generally brown, the colour of the larva seems to depend on the food source. At normal temperatures, the larva may live for 258 to 639 days. Five to 11 moults occur normally but up to 20 may occur under unfavourable conditions. Pupation lasts for 6 to 24 days. Adults live for just over a month and egg-laying may commence within one week of emergence. From 42 to 114 eggs may be laid in multiple batches of one-week separations.

Linsley (1946) studied dermestids in California where he found that a number of species required pollen in their diet for successful production of eggs. He found that these beetles were commonly brought into buildings with cut flowers or potted ornamentals and that these new infestations, consisting of mated and fed females, were a greater

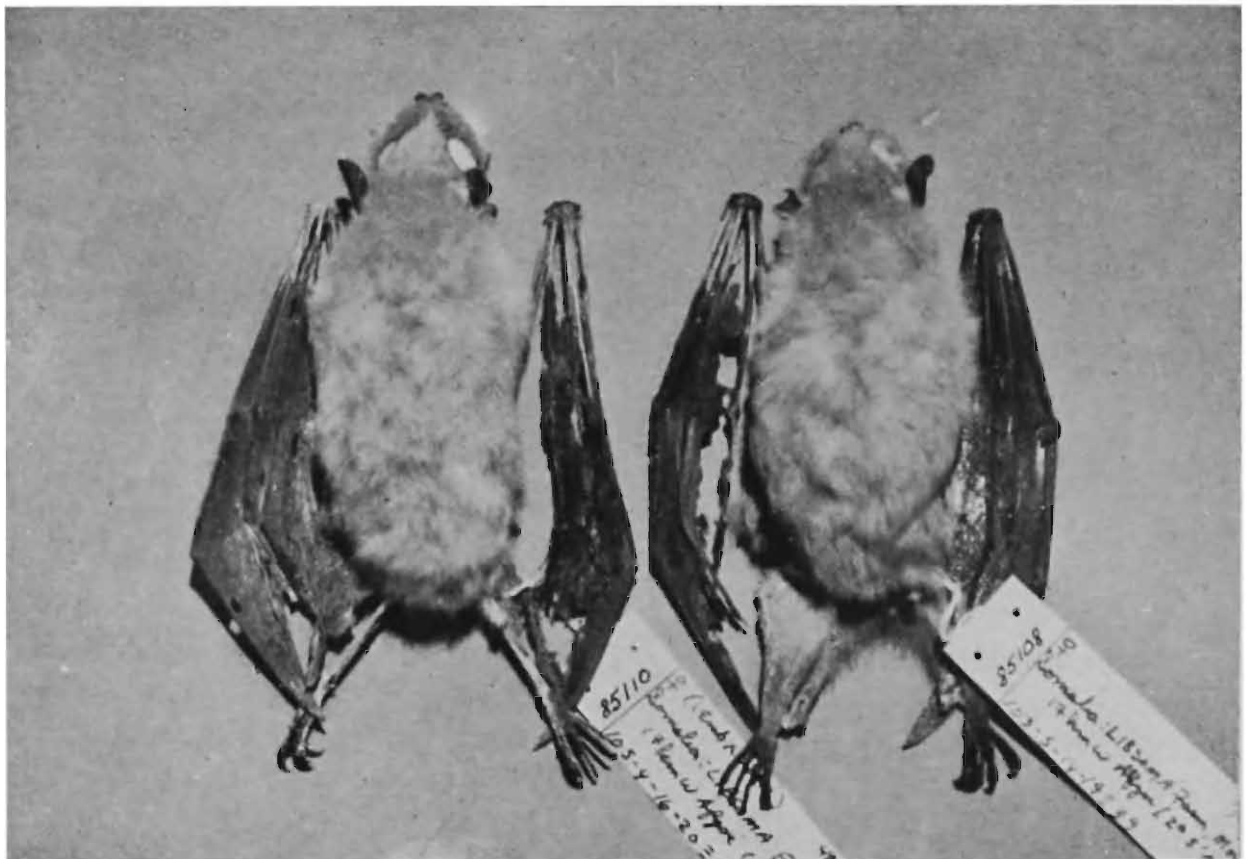


Fig. 2.—Two mammal specimens showing the results of attack by dermestid beetles.

threat for serious outbreaks than were those individuals which might have reached sexual maturity within the confines of the building.

Woodsdalek (1912) studied the life history of the Cabinet Beetle, *Trogoderma ornatum*. He found that the larvae of this beetle would

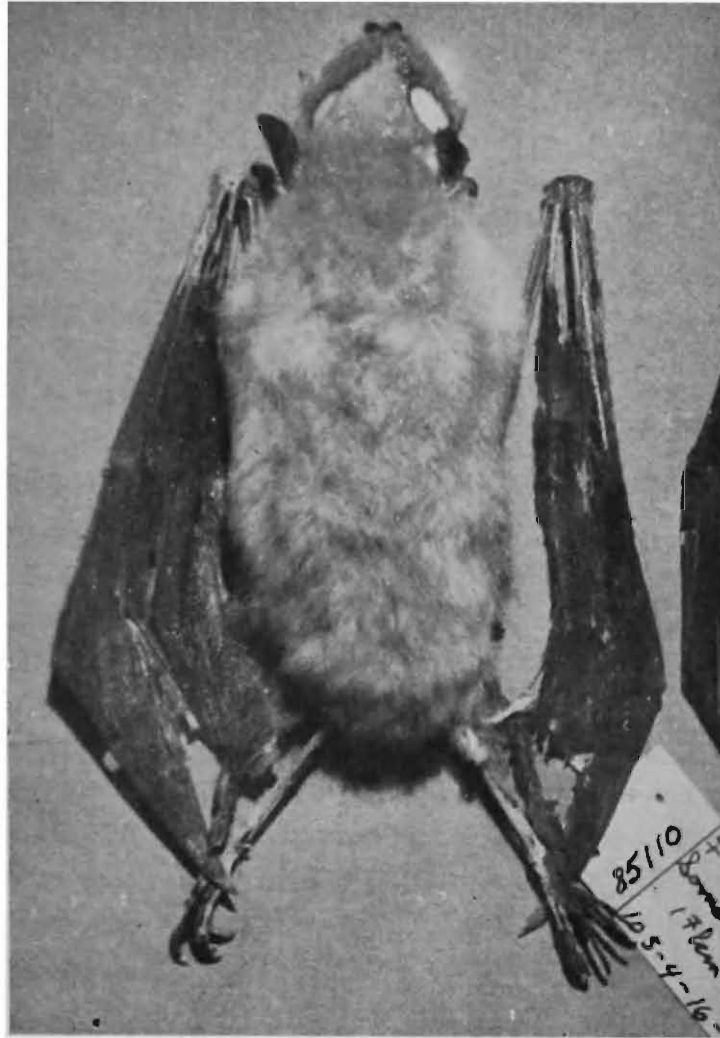


Fig. 3.—Close up view of one of the bats in Figure 2. Note dermestid damage to the wing membranes. A narrow uropatagium has been completely destroyed.

feed on the commodity upon which they hatched if it is edible, and would wander away only when this food was almost entirely consumed. More interestingly, he had one larva that lived for 1884 days without any food whatsoever during this time. Although shrinking drastically during periods of forced starvation, when offered food, these same larvae began rapidly regaining normal size and vigour.

The Odd Beetle, *Thylodrias contractus*, is notable for the sexual dimorphism that exist between adult males and females. The female is larviform in the adult stage.

#### *Family Cleridae*

Probably a number of species in this cosmopolitan family are pests of museum collections. A single species, *Necrobia rufipes* De Geer, commonly referred to as the Red-legged Ham Beetle, will be discussed as an example of the family (Mallis, 1964; Edwards *et al.*, 1981). The adult is from 3.5 to 7 mm in length with a dark metallic blue dorsum and red

legs. The larvae do not resemble dermestid larvae. They are 9-10 mm in length, cylindrical in shape, white in colour, and possess a contrasting dark brown head. Both adults and larvae may cause damages, primarily to dead animal flesh, with the adults being generally surface feeders. These beetles are cannibalistic and will feed on dermestids, carrion, bones, and meats as well. Up to 2000 eggs may be laid by a single female. Only 30 days may be required for the egg-to-adult stages to occur. Several generations may occur per year and, when handled, adults may emit a strong odour.

#### *Family Anobiidae*

Two species of this family of beetles have been identified as serious pests in museum collections even though these beetles do not feed on museum specimens (Mallis, 1964; Edwards *et al.*, 1981). Rather, they feed on items associated with the specimens, namely wood, bookbinding, and especially paper, including books and other paper records. These two species are the Drugstore Beetle, *Stegobium paniceum* (Linnaeus), and the Cigarette or Tobacco Beetle, *Lasioderma serricorne* (Fabricius). In both instances, the adults are reddish brown in colour and small in size, measuring 2.2 to 3.7 mm in length. The white, C-shaped larvae are about 3 to 4 mm in length. Both the larval and adult stages cause damage. The life cycle of the Cigarette Beetle is from 45 to 70 days while that of the Drugstore Beetle is from 6 to 7 months. Cigarette Beetles lay an average of 42 eggs which hatch in from 6 to 10 days. In warm regions, there may be five or six overlapping generations per year.

Mallis (1964) reported that the Drugstore Beetle had such an appetite for books that in one instance this pest bored in a straight line through a whole shelf of books. Drugstore Beetles lay the eggs singly in the foodstuff. The larval stage may range from 4 to 5 months. In fairly warm environments, up to four broods per year are known.

#### *Family Lyctidae and Family Bostrichidae*

Two further families of beetles include species that are of less importance as pests in museum collections. These are the Powderpost Beetles, *Lyctus* sp. in the Lyctidae, and the Bamboo Powderpost Beetles, *Dinoderus minutus* (Fabricius) in the Bostrichidae. As adults both of these groups of beetles are dark brown in colour and small, measuring between 2 and 5 mm. The larvae are small, measuring less than 5 mm, and white with a dark brown head. The larvae are the only damaging stage for the Powderpost Beetles, but both larvae and adults cause damage in the Bamboo Powderpost Beetles. Damaged are primarily items made from wood or other plant material. Bamboo is especially vulnerable to damage but any wood used in making storage cabinets, specimen drawers, or shelving

may be attacked. Dust resulting from the boring and the emergence holes are especially noticeable.

The Powderpost Beetles deposit their eggs in surface pores of wood. The Bamboo Powderpost Beetles lay their eggs in specially constructed egg tunnels or in pores leading from the egg tunnels. The latter beetles have an average life cycle of 51 days with 41 days devoted to larval development and 4 days for the pupal period. In the Powderpost Beetles, the larval stage may cover a period of 2 to 9 months, depending on the species and condition of the food source. Pupation in this group of beetles is slow, taking from 12 days to 3 weeks. Mating and egg laying commences within 2 days of emergence and an average of 51 eggs are laid which incubate in about 8 days.

Both of these groups of beetles are dependent on starch as a food so prefer items made of seasoned hardwoods as a food source. Softwoods and conifers are not readily attacked. Because these beetles readily breed in common commercial items such as furniture and tool handles, they are now cosmopolitan in distribution.

#### *Family Tineidae*

Clothes moths of the family Tineidae are of equal importance with dermestid beetles in their destructive capabilities in museum collections. In the United States, two species are regarded as the primary pests (Mallis, 1964; Edwards *et al.*, 1981). These are the Webbing Clothes Moth, *Tineola bisselliella* (Hummel), and the Casemaking Clothes Moth, *Tinea pellionella* Linnaeus. Ferguson (1950) showed that in the United States these moths were more common in the southern states, whereas dermestid beetles were more important pests in the northern states. He attributed this difference in part to the fact that higher humidities are more conducive to development in clothes moths while the dermestids are better able to withstand the colder weather and lower winter humidity in the northern states. The higher humidities and more stable temperatures in tropical environments are more favourable for clothes moths.

Adult Webbing and Casemaking Clothes Moths are characterised by having narrow wings that are fringed with long hairs. They are yellowish or golden-coloured and small in size, measuring between 7 and 10 mm in length. They prefer darkness and, when disturbed, will run rapidly or fly to conceal themselves. Females ordinarily do not fly. Only the larvae feed in these moths.

Upon emergence, the adults may mate and lay eggs the first day. Adults live for about 14 days, depending on the temperature. The oval,



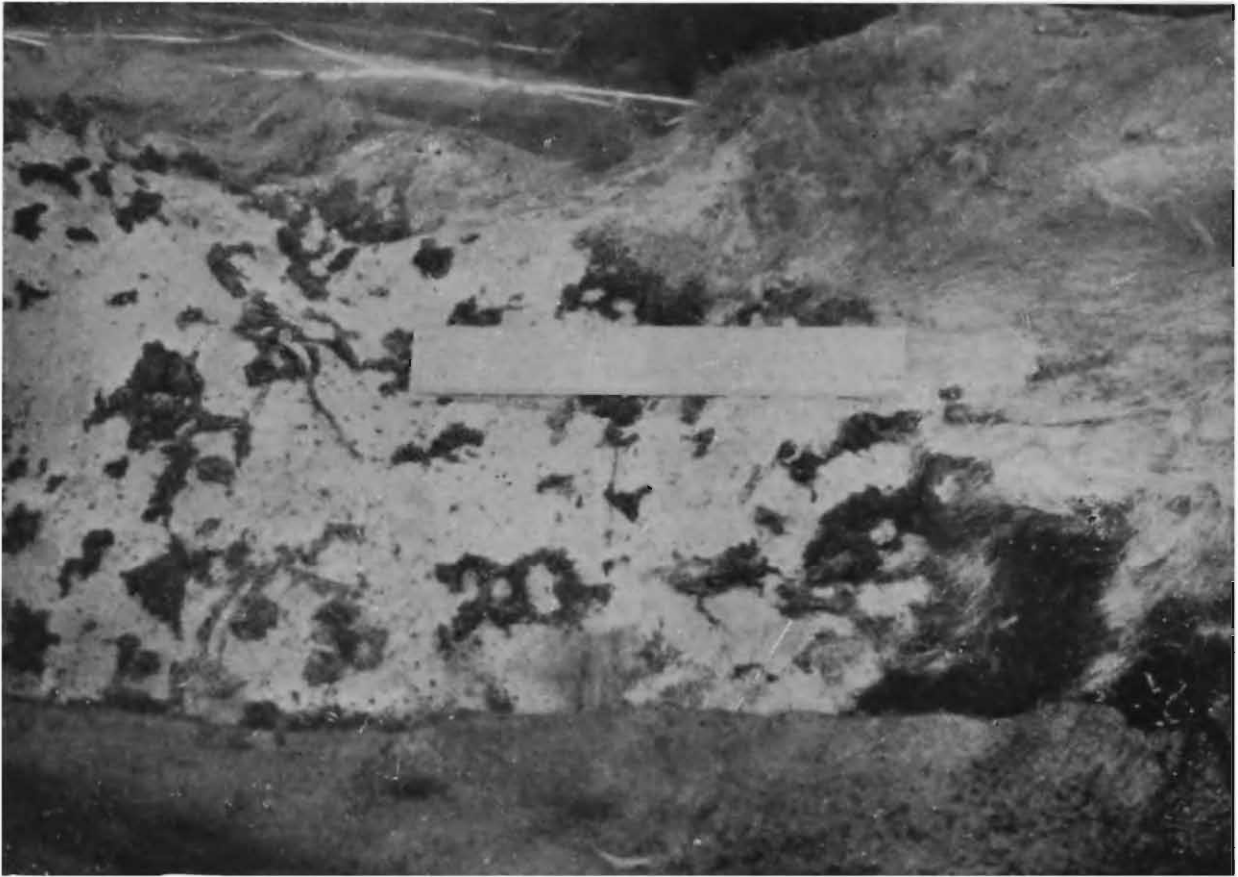


Fig. 4.—Webs from Webbing Clothes Moth on an ethnological specimen. The entire specimen was covered with hair before the attack of these moths.



Fig. 5.—Cases on this ethnological specimen indicate that the damaging pest was the Casemaking Clothes Moth.

ivory white eggs are laid singly or in groups of two or three. Females lay an average of 50 eggs but may lay over 200. Although the females die after laying all of their eggs, males often live several weeks longer and continue mating throughout their life span.

Hatching of eggs occurs in from 4 days to 3 weeks, depending on environmental conditions. In heated buildings, larvae will emerge and feed during the cold season. Overwintering in the egg does not occur since the embryo can not withstand a long incubation. The emerging larvae are white, translucent, and about 1 mm long. Full grown larvae may reach 12 mm in length. Starving of larvae seems to have no measure of control since older ones may live without food for some time and, as adults, are capable of producing fertile eggs. Larvae of Webbing Clothes Moths spin a feeding tunnel of silk which incorporates some of the fibers on which it is feeding, as well as its excrement (Fig. 4). On the other hand, larvae of Casemaking Clothes Moths rarely spin a web. Rather, the larvae produce a case of silk and interweave this in some of the fibers on which they are feeding. The case is carried along as the larvae moves. As they grow, the larvae enlarge the case on each side or end by making slits and filling these with new case material. When ready to pupate, the larvae seek a protected place and close up the cases (Fig. 5). The Webbing Clothes Moth larvae produce a case when ready to pupate. Pupal development takes about 10 days. An average of two generations per year occur. Pheromones from females seem to attract males and induce courtship behaviour.

Clothes Moths target items such as hair, hides, wool, fur and feathers (Fig. 6). Normally the hair or fur is eaten but, in severe infestations, the skin may be eaten as well (Fig. 7).

#### *Family Lepismatidae*

The Silverfish, *Lepisma saccharina* Linnaeus, and the Firebrats, *Thermobia domestica* (Packard), are common pests of items associated with the actual specimens in a museum collection (Mallis, 1964; Edwards *et al.*, 1981). As such they are not often recognised as pests, until after the damages have occurred. The nymphs and adults of these two insects, and some other relatives as well, feed on paper, bookbindings, starch foods, and book glue. They readily remove the glaze from paper, thus they may destroy written records, catalogues, and registers, or other papers associated with the museum collection. They may infest and severely damage libraries as well as stored books or museum publications. Both starches and proteins may be consumed by silverfish.

Silverfish and their relatives are cosmopolitan. Numerous species occur in the tropics as well as temperate regions. The Firebrat is grayish



Fig. 6.—An ethnological specimen in which almost all of the hair has been removed by clothes moths. Note that the underlying skin shows little damage.



Fig. 7.—In heavy infestations by clothes moths, even the underlying skin will be damaged.

in colour with dark markings and reaches a maximum length of 13 mm. It prefers localities where the temperature is over 32°C. The Silverfish has a silvery sheen on its body and attains a maximum length of 13 mm. Silverfish prefers a temperature range of 22° to 27°C.

Eggs are white when laid but turn brown in a few hours. They are usually deposited in crevices. The incubation period depends on the temperature with hatching at 43 days at 22°C and 19 days at 32°C. From 50 to 100 eggs are usually laid, usually singly or in small groups of two or three each. After the instar stages, the nymphs grow rapidly and develop scales after the third moult. Reproduction begins after about 3 or 4 months and the entire life cycle is 2 or 3 years. One to three generations may occur each year. These insects are nocturnal and secretive.

#### *Families Blattidae and Blatellidae*

Two families of cockroaches are generally considered to be pests in museum collections (Edwards *et al.*, 1981). The following species are important although other, local species may also be important—German Cockroach, *Blatella germanica* (Linnaeus); Brown Banded Cockroach, *Supella longipalpa* (Fabricius); Oriental Cockroach, *Blatta orientalis* Linnaeus; and American Cockroach, *Periplaneta americana* (Linnaeus). Cockroaches feed on leather, parchment, and wood, as well as the more commonly eaten starchy materials, sugars, and fermented foods.

A large amount of variation exists in the life history of cockroaches (Mallis, 1964; Edwards *et al.*, 1981). Both nymphs and adults cause damage. Cockroaches are shy, nocturnal insects. Some species prefer hot, drier conditions while others prefer moist ones. Thus control measures that involved heat or humidity control will have little impact on cockroaches unless targeted toward to specific species.

The eggs are laid in an egg case or ootheca that is usually dark brown and attached to some object or deposited in a crevice. Females lay from 6 to 14 egg cases with an average of about 9. Each egg case may contain up to 16 eggs in two equal rows. Incubation varies from 38 to 49 days depending on environmental conditions.

Nymphs hatch within a short span of time and leave the egg case at the same time. As many as 13 moults occur before the adult stage is reached after an average of 400 days. Sexual maturity may be attained after only 7 months.

Depending on the species, from one to four generations occur per year and each generation may live up to 30 months. Parthenogenesis occurs in cockroaches.

## GENERAL PEST MANAGEMENT PLAN

Every collection of mammals must have a pest management plan. This plan must include all mammals in the museums including specimens on exhibit, in public areas, material for sale at museum shops, and those on open storage such as mounted heads in the collection area or offices as well as those in the research collections.

Any management plan must start at the outside of the building. It is far better to exclude insect pests from the collection than to try to kill them after they have entered the collection. Air conditioning of the collection area is an excellent step in preventing insects from entering the collection area. This allows all doors and windows to be kept closed during all types of weather. If air conditioning is not possible, all windows, doors, and vents must be screened. All window sills and door frames should be inspected for cracks or crevices that would allow insects to enter. These must be sealed.

The next line of defence is the collection area itself. In this area, the defence begins with good housecleaning (Peltz and Rossol, 1983). The area should be kept clear of trash, boxes, and collection supplies. These provide excellent hiding areas for all types of insects. The areas around and under cases, in all corners, and the tops of double-stacked cases should be kept clean of dust and lint. A vacuum cleaner is excellent for these purposes but is not absolutely necessary. All members of the museum staff should be made aware of the necessity for keeping all areas clean. The final defence in the collection area is the cases themselves. These should be kept closed unless work is being conducted in them. All specimens should be kept in the cases unless they are being actively used.

The final solution for insect pests is fumigation of the collection itself. It must be emphasised that this is the *final* solution and that it should be used as such. The fumigants are dangerous poisons and their use always places the specimens and staff at risk.

The collection should be inspected on a regular basis for any signs of insect activity. This should include the entire collection and should be done at least every six months. If insect activity has been found in the past, the curator may want to have more frequent inspections. The collection staff should be alert for signs of activity whenever working in the collection. Curators should be certain to instruct all staff members on what these signs of activity are. They should be shown adult and larval clothes moths and dermestid beetles. They should be able to recognise the larval exoskeletons and excrement left by feeding larval dermestid beetle (Fig. 1). Clothes moths make characteristic webs or

cases (Figs. 4 and 5). Careful instruction of all staff members in recognising these signs may prevent serious damage to a portion of the collection.

If the collection is to be fumigated, this should be done on a regular basis. A record should be kept of each fumigation and this record should be posted in the collection area. Fumigation of the entire collection probably should be done no more than once a year, unless the collection has been experiencing unusual insect pest problems, then twice a year will be sufficient. We are basically against continuous use of insecticides in the collection because of the continuous exposure of the staff and collections to these potentially harmful substances.

The two manners in which insects are most likely to be introduced into the collection area are with incoming field collections and with loans. One case should be set aside for fumigating this material. It is best that this case be located away from the collection area to reduce risk of insects being brought in with them. All packing materials that will be saved should be fumigated as well. A colony of dermestid beetles is extremely useful to the operation of a collection of mammals. However, this colony should be maintained in a building separate from the collection to reduce the risk of accidental introduction of these beetles as pests into the collection.

Exhibition material and specimens on open storage can be protected by contact poisons such as arsenic, aldrin, or Edolan-U. If these are not used, exhibit specimens can be protected by hanging a vapona (DDVP) strip in the exhibit case. Material on open storage can be placed in plastic bags with vapona or paradichlorobenzene (PDB).

Curators should remember that other items beside the specimens can also be the target of insect attack. Wooden items and paper can be attacked. These items must also be inspected on a regular basis.

#### GENERAL PROCEDURES FOR APPLYING INSECTICIDES

Although the exact procedures for applying insecticides will vary from one collection to another and with the particular insecticide being used, there are some general procedures that must be considered when applying any insecticide. The first and most important consideration is for the long- and short-term health needs of the staff. The next most important consideration must be for the long-term preservation of the specimens. These two needs must be considered by any curator before selecting and using any insecticide (Williams *et al.*, 1977; Williams *et al.*, 1985).

All collections should have a written insecticide procedure. This procedure is based upon the label instructions on the insecticide container (Fig. 8). No one should mix chemicals to make his own insecticide mixture.

No insecticide application should be performed alone. All workers must be trained and familiar with the insecticide methods, precautions, and emergency procedures. There should be a written emergency plan and first aid kits equipped to handle any emergency relating to the insecticide that is being used. The workers must have available all of the appropriate equipment and facilities to prevent exposure to the insecticide. All workers should be trained in the use of the available equipment and facilities.

Insecticides that are not being used should be isolated in a locked storage cabinet. The containers need to be well-marked. Insecticides that are to be discarded must be disposed off in a manner safe to personnel, facilities, and the environment.

No smoking or other sources of ignition can be allowed in the collection storage area while the insecticide is being used.

### INSECTICIDES

In this section, insecticides that have been used in museum collections are listed. We have listed these in categories according to their desirability for use in museum collections (see also Williams *et al*, 1985). This listing represents the current knowledge concerning these insecticides. New products are coming onto the market all of the time and new information about old insecticides is becoming available. The curators of collections of mammals must keep abreast of this information in order to give maximum security to their collections and staff.

These insecticides may come in the form of gas, liquid, or solid. Those that are in the form of poisonous gases or liquids and solids that evolve a poisonous gas are termed fumigants. These are dangerous poisons and should be handled as such. Curators must be certain that staff members who apply a fumigant are thoroughly trained and provided with all of the necessary equipment. *Read and understand* all label instructions on any insecticide before use (Fig. 8). Other insecticides that are listed in this section are contact poisons or baits.

### INSECTICIDES RECOMMENDED FOR USE

*Dimethyldichlorovinyl phosphate* ( $C_4H_7O_4PCl_2$ ; Vapona, DDVP, no-pest strip).— This insecticide is a liquid that can be used as a spray, in

# No-Pest

## INDUSTRIAL STRIP INSECTICIDE

### KILLS FOR UP TO 4 MONTHS

#### Active Ingredients:

2, 2-Dichlorovinyl Dimethyl Phosphate	19.2%
Related Compounds	0.8%
Inert Ingredients	80.0%
Total	100.0%

EPA Registration No. 3696-117

EPA Est. No. 677-MJ-1

KEEP OUT OF REACH OF CHILDREN

### CAUTION

PRECAUTIONARY STATEMENTS  
HAZARDS TO HUMANS AND DOMESTIC ANIMALS  
CAUTION:

Do not get strip in mouth; harmful if swallowed. Wash hands thoroughly with soap and water after handling strip. Do not use in restaurants or edible-product areas of food processing plants.

—120 STRIPS—

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Manufactured for:  
Greenville, South Carolina 29602  
Division of MORTON THIOKOL INC.

#### DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

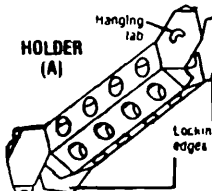
#### STORAGE & DISPOSAL

Do not contaminate water, food or feed by storage or disposal. Wrap used strip and place in trash.

#### USE AND APPLICATION DIRECTIONS

For best results from your No-Pest® Strip: Do not remove strip from foil envelope until ready to use. Use one No-Pest® Strip per one thousand cubic feet of enclosed area (10' x 12' x 8').

#### HOW TO ASSEMBLE

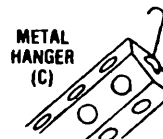
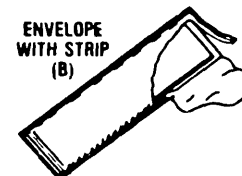


##### HOLDER (A)

1) Press outer edges of holder (A) to form as shown. Push out hanging tab on top flap and fold locking edges down before forming top. Fold over top flaps (small flaps first) and engage locking edges firmly into holder. Do not attempt to open top once it has been locked.

##### ENVELOPE WITH STRIP (B)

2) Cut open envelope (B) with scissors. Remove No-Pest® Strip and place inside holder through open bottom. Fold down locking edges. Form and lock bottom of holder. Do not allow the strip to touch textiles or painted surfaces — it may stain.



##### METAL HANGER (C)

3) To hang unit, attach metal hanger (C) to the tab on top of holder.

Hang or stand upright to allow air to circulate freely on all sides. Do not place in strong drafts or near doorways. Weather and excessive ventilation in an area may reduce effectiveness. Replace with a new strip when effectiveness diminishes. The No-Pest® Industrial Strip also may be used without the cage.

No-Pest® Strip is designed for use in control of exposed stages of stored products insects infesting warehouses containing non-perishable, packaged or bagged raw or processed food commodities. The term "non-perishable" means any raw or processed food not subject to rapid decay or deterioration that would render it unfit for consumption. Raw commodities include cocoa beans, coffee beans, field dried beans, field dried peas, grains and nuts. Processed foods include flour, sugar, cereals, packaged goods and crackers.

The No-Pest® Industrial Strip also may be used in non-food areas of industrial food processing and packaging plants and bakeries. Non-food areas may include utility rooms, offices, lavatories, garages, storage rooms or basements. The No-Pest® Industrial Strip may be used in enclosed receptacles and other enclosed spaces to control insects.

U.S. Patent 3,769,416

Cr 1e 00891-1182

63895

Fig. 8.—An example of label information that accompanies an insecticide. This label is from dimethyldichlorovinyl phosphate.



bait (Negherbon, 1959), or in evaporative strips. The latter can serve as a fumigant for storage cases, thus making it applicable for mammal collections. However, in highly humid conditions such as in the tropics, an acid is formed that may corrode metal and drip onto specimens ; care must be taken in the placement of strips to avoid damage. One strip (16 cm  $\times$  6 cm  $\times$  0.5 cm) can be used for each 28.3 m<sup>3</sup> of closed storage space.

Johnson and Kritzman (1985) reported on 18 years of using Vapona in the Puget Sound Museum of Natural History. In each of the standardized museum cases (.91 m<sup>3</sup>), they introduced one-thirtieth of a vapona strip ; these were replaced every three months. They never experienced a single instance of specimen damage or active infestation during this period. Museum personnel reported no actual or suspected ill effects from the insecticide. They found no evidence of colour changes or other deterioration of specimens kept with strips for up to 18 years.

The Section of Mammals, Carnegie Museum of Natural History, is now using DDVP as a fumigant, but with a procedure different from the Puget Sound Museum of Natural History. It was found by Stephen L. Williams that one-thirtieth of a strip in a 28.3 m<sup>3</sup> case will not kill adult and larval dermestid beetles in 7 days of continuous exposure. The success at the Puget Sound Museum of Natural History with this concentration is probably a result of its repelling power rather than its killing power. One-fourth of a strip was found, however, to inactivate all adult and larval dermestid beetles after five days of continuous exposure. The collection is now fumigated twice annually with a quarter strip per case for periods of 10 days. The strip is introduced at the top of the case in a wooden holder which gives maximum exposure to the surface of the strip. This insures the rapid build-up of lethal levels of the DDVP. If the strip is placed in a holder with sides, a high concentration is formed near the strip but will not rapidly diffuse throughout the case.

This method has several advantages. It builds a lethal level of the insecticide so it is acting as a fumigant and not just a repellent. It can be used to treat incoming materials which may already contain live pests. It gives minimum exposure of the staff to the pesticide. DDVP is supposed to be relatively harmless to humans, but there are many things which we do not know about at present. Some members of Carnegie Museum of Natural History staff have complained of headaches in collection areas with DDVP in cases. This is probably caused by one of the plasticizers in the strip. The new strip from Texize Corporation is not supposed to include this plasticizer in the strips. However, it is important to remember that the collection area should be well-ventilated while the strips are in the cases and that the cases should be aired for 24

hours after the strips have been removed. This method also reduces the exposure of the specimens to the fumigant. There is still far too little known about the effect of DDVP and other fumigants on the specimens and their longevity. The first breakdown product of DDVP in the presence of water is phosphoric acid. The new strips are not supposed to "sweat" or "drip" as did the old strips, but no testing has been done in tropical environments. However, beyond the effects of these obvious concentrations of acid, we do not know the effects on specimens of the low concentrations that result from the DDVP which has vaporised. The obvious solution to this problem is to expose the specimens to the fumigant for as short a period as possible.

The effect of exposure to human beings is relatively mild when used in recommended dosages. Higher dosages may affect the central nervous system, eyes, respiratory system, and cardiovascular system. Acute exposure may result in relatively mild symptoms such as the inability to walk and chest discomfort to more violent symptoms such as unconsciousness and seizures (Peltz and Rossol, 1983). It is also possible that birth defects may result from exposure (Edwards *et al.*, 1981; Peltz and Rossol, 1983).

*Paradichlorobenzene* ( $C_6H_4Cl_2$  PDB).—At room temperature this insecticide exists as colourless crystals that will sublime to form an effective fumigant. It is usually used in open containers placed in the upper parts of storage cases because the fumes are heavier than air. The advantages are that it provides an easy, effective, and continuous fumigation method which is noncorrosive, non-staining, and relatively safe from fire hazards. One of the side benefits of this fumigant in the tropics is that it is anti-fungal. If mildew is found in the collection, dissolve PDB in 70% ethyl alcohol and spray the mixture on the specimens. One disadvantage of PDB is that in high concentrations as a fumigant, crystallisation can occur anywhere on specimens and storage cases. Clear plastic skull vials have been found to be seriously etched by PDB with opacity and severe deforming of the plastic occurring after long exposure or when stored at high temperatures (Johnson and Kritzman, 1985).

For the effective use of this insecticide about  $0.4\text{ kg}/2.83\text{ m}^3$  (9 pounds per 1000 ft<sup>3</sup>) is recommended (Edwards *et al.*, 1981). The main disadvantage is that its continuous use imposes a continuous health problem for personnel. Exposure is primarily by inhalation and skin contact, but may also include ingestion. Body parts affected by exposure include the eyes, skin, kidneys, liver, respiratory system, and central nervous system (Edwards *et al.*, 1981). With one or two years exposure, hepatitis, cirrhosis, and eye cataracts are possible (Negherbon, 1959; Peltz and Rossol, 1983). Acute exposure may result in dizziness, headaches, nausea, and loss of coordination (Edwards *et al.*, 1981; Peltz and Rossol, 1983).

*Carbon dioxide* (CO<sub>2</sub>).—Carbon dioxide is a colourless and odourless gas that comprises 0.03% of the earth's atmosphere. It is an ideal fumigant because of its killing ability in higher concentrations and its relatively limited hazard to health, specimens, or facilities. Carbon dioxide should be used in concentrations of 60% for four days when temperatures are over 20°C. Lower concentrations may be used for longer periods of time ; higher concentrations have little added effect (Jay, 1971). Lower humidity will cause CO<sub>2</sub> to be more effective (Jay *et al.*, 1971). One kilogram of liquid CO<sub>2</sub> will provide 0.54 m<sup>3</sup> of gas at 100% concentration (Jay, 1971). The Field Museum of Natural History has investigated the feasibility of using CO<sub>2</sub> to fumigate collections. One of the main problems encountered is obtaining totally sealed specimen cases that will hold the positive pressure caused by the CO<sub>2</sub> gas. This fumigant offers good potential for use in mammal collections, but more research will be needed to determine appropriate methods and equipment for its use. Exposure to CO<sub>2</sub> is dangerous to humans only in high concentrations, which will cause difficulty in breathing. Because it is heavier than air, accumulations may occur in unventilated areas. Caution should also be taken in handling storage tanks of liquid CO<sub>2</sub> which have an inside pressure of 21.1 kg/cm<sup>2</sup> (Jay, 1971).

*Pyrethrum*.—This is a viscous, brown, liquid oleoresin that is a contact poison which may be used in a spray or dust form. It is among the safest, most useful, and effective pesticides (Negherbon, 1959). It is derived from the flowers of *Chrysanthemum cinerariaefolium* with the active ingredients being six closely-related esters (Schofield and Crisafulli, 1980), which are termed "pyrethrins" Because pyrethrins break down rapidly in sunlight, they will not accumulate in the collection or in the environment.

Because of the instability of pyrethrum, it is usually mixed with a synergist that will prolong its life. Because it is a contact pesticide (Edwards *et al.*, 1981), it should not be applied to specimens because of potential damage to the specimens and exposure to anyone handling the specimens. Pyrethrum can be applied as a spray or in powder form. As a spray, it can be introduced into a museum case killing any live insects. As a powder, it is mixed with silica gel and synergists to give long-term protection and is sold in the U.S. under the commercial name "Drione" (Schofield and Crisafulli, 1980). The silica gel helps increase the killing power of Drione because it will abrade the waxy cuticle of insects and is a desiccant. We do not recommend, however, the use of Drione dust in museum cases. The dust will become entangled in the hair of specimens and may change the colour reflectance, and we are not certain of the long-term human health effects of breathing this fine dust.

Drione can be used very effectively in mammal collections as part of an overall pest management programme. Drione can be applied as a bulk powder or as an aerosol powder. In either of these forms, it is recommended for use around and under museum cases and in cracks around windows and doors or other places where it is suspected that insects may be entering the collection area. The bulk dust may be applied with a rubber squeeze bulb. When applying either form of Drione, the worker should wear rubber gloves, plastic goggles, and a respirator equipped with replaceable filter cartridges approved for use with highly toxic dusts and sprays.

Although the toxicity of pyrethrum to man is relatively restricted, this pesticide can still affect the skin, respiratory system, and central nervous system (Edwards *et al.*, 1981). The unrefined extract can cause an allergic reaction in anyone prone to hay fever. The refined extract is metabolised in the human body to water-soluble compounds that are excreted without ill effects (Schofield and Crisafulli, 1980).

*Baygon*.—This is the trade name of a bait or contact poison made with the active ingredient of 2-(1 methylethoxy) phenol methyl carbamate, also simply called methyl carbamate. The insecticide is placed on an inert carrier such as ground corncobs along with an attractant to form the bait. Baygon is a very effective bait for cockroaches. The bait should be placed in dark, out-of-the-way places that would be frequented by the roaches. Only small amounts should be used at any one time because the methyl carbamate becomes inactive after about 2 weeks.

#### INSECTICIDES AVAILABLE FOR USE

*Dowfume 75*.—Dowfume 75 is a mixture of 70% ethylene dichloride ( $\text{CHCl}_2$ ) and 30% carbon tetrachloride ( $\text{CCl}_4$ ). The latter is added to reduce the flammability (Edwards *et al.*, 1981). This clear liquid is used in open containers where it evaporates to form a highly toxic fumigant. Because the fumes are heavier than air, the evaporation containers should be placed near the top of the storage cases. No damages caused by the fumigant to specimens, textiles, or metals have been reported. However, some plastics and rubber are softened when exposed to the fumigant (Edwards *et al.*, 1981; Negherbon, 1959; Peltz and Rossol, 1983).

Quantities of 0.4-0.8 kg/2.83 m<sup>3</sup> are recommended (Edwards *et al.*, 1981); duration should be about four days at normal temperature. The entire collection area must be evacuated while the Dowfume is in the cases. The cases must be opened and aired for at least 24 hours before the staff is allowed back into the area. The staff members who introduce the fumigant or open the cases for airing must wear full-face respirators (no one with a beard should apply this fumigant) equipped with black

canisters. They should wear cotton coveralls over their clothing and cotton or rubber covers over their shoes. They should not wear gloves. If fumigant is splashed onto their hands, gloves tend to hold it against the skin where it is absorbed.

The containers for the fumigants in the cases should be glass because this fumigant corrodes metal. The best way to introduce the fumigant into containers is with a compressed-air hand sprayer. The spray nozzle should be removed so that single stream of fumigant is introduced. Care must be taken so that the pressure is not too high. High pressure will cause the fumigant to splash back out of the receptacle.

Exposure to Dowfume 75 is dangerous. Both ethylene dichloride and carbon tetrachloride can enter the body by being inhaled, ingested, or absorbed through the skin. Chronic effects of carbon tetrachloride and ethylene dichloride include problems with the skin, liver, kidney damage, gastrointestinal tract, eyes, and cardiovascular and central nervous systems. There may be diminished urinary flow with red and white blood cells and albumin in the urine. Both poisons are suspected of causing cancer in man. At least carbon tetrachloride is also suspected of affecting reproductive systems. Acute exposure may result in death (Edwards *et al.*, 1981). This fumigant has a synergistic effect with alcohol that is consumed either before or after exposure. This combination has resulted in many fatalities (Peltz and Rossol, 1983).

*Naphthalene* ( $C_{10}H_8$ ).—At room temperature, naphthalene exists as white crystals that will sublime to form a low toxicity fumigant (Negherbon, 1959). It is best used as a repellent in collection storage cases. Its effectiveness as an insecticide is questionable (Edwards *et al.*, 1981). Naphthalene is usually used in open containers in storage cases. There are no reported damaging effects to specimens or storage cases. However, recrystallisation may occur on any surface (Edwards *et al.*, 1981).

Quantities of 0.45 kg/2.8m<sup>3</sup> is recommended for effective use (Williams *et al.*, 1977). Naphthalene can be dangerous with exposure to large doses by skin absorption, inhalation, or ingestion. Direct contact to the eyes by dust can produce irritation and cataracts. Inhalation of large dosages may cause hemolysis of red blood cells. Severe hemolytic anemia can result even at low exposure if the person has glucose-6-phosphate dehydrogenase deficiency.

*Arsenic* ( $As_2O_3$ ).—Arsenic is a contact poison that has been widely used for powdering study skins of mammals. Although this poison is effective for killing insects that are eating specimens, it is hazardous to preparators and individuals handling the specimens because of skin

absorption and/or inhalation. Prolonged exposure results in loss of hair and nails, and eventually death. There are some data that arsenic may be a cancer-causing agent in humans (Lederer and Fensterheim, 1983).

#### INSECTICIDES TO BE USED ONLY UNDER RESTRICTED CONDITIONS

*Aldrin and dieldrin.*—These are contact poisons that bond with keratin in hair, claws, and horns. The main problem in using these insecticides is finding a safe procedure to apply them to the specimens. Currently in the U.S., aldrin is licensed only for application in effluent-free mothproofing. It is applied in water as an emulsion spray. Because aldrin, and its breakdown product dieldrin, are extremely dangerous, they should be applied only under very controlled conditions that will not expose staff members.

The one use that aldrin may have in a museum context for mammal specimens is for material that will be on long-term exhibition. This would give these specimens protection from pest attack. It is not recommended for research specimens because the aldrin binds permanently with the hair and may have some long-term effects on the colour of the hair.

Exposure affects the skin, kidneys, liver, and central nervous system. Chronic effects may result in a syndrome imitating epilepsy. Acute exposure may result in convulsions possibly alternating with severe depression. The convulsions may be preceded by headaches, visual disturbances, dizziness, and nausea. Aldrin and dieldrin are suspected to cause liver and lung cancer and genetic changes (Edwards *et al.*, 1981).

*Sulfuryl fluoride* ( $S_2O_4F_4$  ; Vikane).—At room temperature, sulfuryl fluoride is a colourless, odourless, nonflammable gas. It is a good, thorough insect fumigant with rapid penetration and no damaging effects on a wide assortment of metals, rubbers, textiles, leathers and other materials (Negherbon, 1959). Because it exists as a highly active gas, it should be used as a fumigant for building structures or in chambers specifically constructed for fumigation, and not in storage cases. A dosage of 0.09-0.18 kg/2.83 m<sup>3</sup> is recommended (Edwards *et al.*, 1981).

Exposure to this gas affects the eyes, respiratory system, central nervous system, and kidneys. Such symptoms as conjunctivitis, nausea, vomiting, tremors, and convulsions may be expected. Long-term exposure may result in defects in bones and teeth (Peltz and Rossol, 1983).

*Edolan-U* (Mitin).—This is a contact poison that bonds with keratin in hair, claws, and horns. This is an aromatic sulphonamide derivative

that does not kill or repel the insects but makes the material unsuitable for consumption.

Edolan-U will find its main use in treating mounted specimens that will be on long-term exhibition. The Edolan-U is applied in a water solution, which is concentrated in a solution strong enough to turn the water a milky opaque colour. This solution should be heated to 48.9°C (120°F). The hair should be cleaned by wiping it with a cloth dampened with white gasoline. The Edolan-U solution is then sprayed onto the hair, being certain that it is damp down to the skin. After a 15-minute waiting period, the hair should be quickly dried by any appropriate method (Funk and Sherfey, 1975).

Exposure can occur by skin contact, inhalation, or ingestion, and will affect the skin and eyes (Edwards *et al.*, 1981). It is possible that further use and investigation of this relatively new product will reveal other health-related problems. Nevertheless, gloves and goggles should be worn to protect the applicator. Because Edolan-U is toxic to fish, it must be used in such a manner as to prevent any effluence (Funk and Sherfey, 1975). Edolan-U, when burned, decomposes, releasing hydrogen chlorides, carbon monoxide, and oxides of nitrogen and sulfur (Edwards *et al.*, 1981).

*Borax* ( $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ ).—This is a contact poison that is sometimes dusted on the inside of study skins during preparation to kill insects that may feed on the specimen. Use of this insecticide will cause colour changes in hair, thus reducing the scientific value of the specimen. Health-related problems resulting from exposure to borax include heart, skin, stomach, and central nervous system (Negherbon, 1959).

#### INSECTICIDES TO AVOID

*Ethylene oxide*.—This fumigant is highly explosive so it is usually mixed with a retardant such as in carboxide, which is 90%  $\text{CO}_2$  and 10% ethylene oxide. This fumigant is very dangerous and should be used only in commercial fumigation chambers. Ethylene oxide reacts with proteins to cause premature aging of protein material such as mammal skins. It settles in fatty materials of specimens ; several weeks of being thoroughly aired are required before it is safe to handle the specimen without fear of skin absorption.

Exposure affects the eyes, skin, blood, central nervous system , and respiratory system. It causes leukemia and genetic changes in humans (Edwards *et al.*, 1981; Peltz and Rossol, 1983).

*Methoxychlor*.—This is a colourless crystalline, contact poison which is a biodegradable form of DDT. It is normally used as a powder or spray and therefore has limited use around mammal specimens because of potential hazards to the specimen and anyone handling the specimen. Exposure to this insecticide may affect the liver, kidneys, and central nervous system.

*Methyl bromide* ( $\text{CH}_3\text{Br}$ ).—This is a fumigant that reacts with materials containing sulfur such as fur, leather, and other materials containing proteins. It also reacts with, and blackens, metals. This fumigant should only be used in commercial fumigation chambers.

Exposure affects the eyes, skin, respiratory system, and central nervous system. Acute exposure may result in headaches, nausea, and tremors, which may become widespread developing into epileptic-like convulsions. Death may result from pulmonary or circulatory failure (Edwards *et al.*, 1981; Peltz and Rossol, 1983).

*Carbon disulfide* ( $\text{CS}_2$ ).—This is a liquid at room temperature that evaporates to form a highly toxic fumigant. Carbon disulfide has been the most commonly used fumigant in mammal collections in the United States for the past 50 years. However, with the growing realisation of the danger of carbon disulfide, it is now not being used in any of the major collections. There were never any serious accidents with carbon disulfide while it was being used, but there are no data on the long-term effects that it had on the staff members who used it. Carbon disulfide is particularly dangerous because it is explosive and flammable (flash point =  $20^\circ\text{C}$ ) (Edwards *et al.*, 1981; Negherbon, 1959).

Acute effects include dizziness, nausea, headache, fatigue, loss of coordination, and unconsciousness. High dosages can result in nerve damage, psychosis, and possibly death. Chronic exposure will affect the nervous system, kidneys, liver, heart, and eyes. Symptoms include severe behavioural and psychological changes, tremors, shuffling gait, memory loss, and impotence. Carbon disulfide is known to cause reproductive damage in humans (Peltz and Rossol, 1983).

*Carbon tetrachloride* ( $\text{CCl}_4$ ).—This nonflammable, nonexplosive poison that is a liquid at room temperature, evaporates to form a fumigant of relatively low toxicity to insects (Negherbon, 1959). Carbon tetrachloride as a vapour will soften waxes and rubber, such as the gas-kets that are used to seal museum cases.

Reactions in humans involve the skin, liver, kidneys, central nervous system, and possibly reproductive system. Liver cancer may also result from exposure. Acute exposure is often fatal, particularly if alcoholic



beverages, which provide a synergistic effect, are consumed during or after exposure (Edwards *et al.*, 1981).

*Ethyl acetate*.—This is a clear liquid at room temperature that evaporates to form an effective fumigant. It is dangerous to use because of its volatility and flammability (flash point=7.2°C). Also, exposure damages the heart, lungs, kidneys, and liver (Negherbon, 1959).

*Ethylene dichloride*.—This is a liquid at room temperature that evaporates to form a fumigant. High flammability (flash point=13.3°C) precludes its use in mammal collections. Ethylene dichloride will settle in fatty tissue, making long-term airing of specimens necessary. It produces highly toxic phosgene gas when burned or exposed to high heat or ultraviolet light in the presence of moisture.

The skin, eyes, liver, lungs, kidneys, cardiovascular system, and central nervous system may be affected by exposure. It may cause cancer ; acute exposure can be fatal (Edwards *et al.*, 1981).

*Hydrogen cyanide*.—This is an extremely poisonous gas that may cause death in humans within minutes (Edwards *et al.*, 1981). Chronic exposure may result in skin rash, itching of throat and nose, burning of the eyes, and a metallic taste in the mouth. This fumigant should not be used in museum collections under any circumstances (Peltz and Rossol, 1983).

#### SUMMARY

Control of insect pests that attack the collection is one of the major concerns for curators of mammal collections. Among the common pests that will damage and destroy mammal skins and fur are the dermestid beetles of the family Dermestidae and clothes moths of the family Tineidae. Dermestid beetles will damage skin areas such as the exposed ears and wing membranes as well as the fur. These beetles can be highly useful in cleaning skeletal material of mammals, but it also increases the possibility of introducing them into the collection area. Extreme care must be taken to prevent this from happening. The clothes moths primarily attack the fur, although in extreme infestations the underlying skin may be damaged as well. There are other pests that attack materials associated with the collections. Drugstore beetles, cockroaches, and silverfish will damage any paper items, especially those with animal glues applied to them. Powderpost beetles and false powderpost beetles will attack wooden items such as storage cases or shelving.

Any pest management plan must start at the outside of the building by trying to exclude the pests. Measures that can be taken include air

conditioning the building, so doors and windows may be closed, screening doors or windows that remain open, and fumigating incoming field collections and loans. Inside the building the cases should be kept closed, good housekeeping must prevail, and the collection should be inspected on a regular basis. The last resort in the management plan should be fumigation of the collection.

If the collection is to be fumigated, certain safety rules must be rigidly followed. Use an appropriate pesticide and precisely follow all label instructions. No pesticide is applied by a lone staff member. The collection area must be well ventilated while the pesticide is in the cases. The collection staff should be prepared for any emergency and appropriate first aid items should be available.

Pesticides that are currently recommended for use in mammal research collections are DDVP, paradichlorobenzene, carbon dioxide, Drione, and methyl carbonate. Other pesticides that are available for use in collections but whose desirability, for various reasons, is lower than the first group include Dowfume 75, naphthalene, and arsenic. There are some pesticides which may have some use in collections of mammals for restricted purposes such as application on display specimens. These may be used under very restricted conditions such as in commercial fumigation chambers or affluent-free application. These pesticides include aldrin, dieldrin, sulfuryl fluoride, edolan-U, and borax. Pesticides that curators should avoid using under any circumstances in collections of mammals are ethylene oxide, methoxychlor, carbon disulfide, carbon tetrachloride, ethyl acetate, ethylene dichloride, and hydrogen cyanide.

#### REFERENCES

- CHOATE, J. R. and GENOWAYS, H. H. 1975. Collections of Recent mammals in North America, *J. Mammal.*, **56** : 452-502.
- EDWARDS, S. R., BELL, B. M. and KING, M. E. (eds.). 1981. *Pest control in museums : a status report* : vii+1-34 (text)+57 pp. (appendices). Association of Systematic Collections Publications, Lawrence, Kansas.
- FERGUSON, G. R. 1950. Survey on incidence of fabric pest damage. *Soap Sant. Chem. off. Proc. 36th Mid-Year Meeting*, : 77-79.
- FUNK, F. and SHERFEY, K. 1975. Uses of Edolan-U in museum preparation and conservation of zoological materials. *Curator*, **18** : 68-76.

- GENOWAYS, H. H. and SCHLITTER, D. A. 1981. Collections of Recent mammals of the World, exclusive of Canada and the United States. *Ann. Carnegie Mus.*, **50** : 47-80.
- GENOWAYS, H. H. and SCHLITTER, D. A. 1985. Survey of the Recent mammal collections of the World. *Acta zool. fennica*, **170** : 41-42.
- JAY, E. G. 1971. Suggested conditions and procedures for using carbon dioxide to control insects in grain storage facilities. *U. S. Dep. Agric., Agric. Res. Serv.*, **51** (46) : 1-6.
- JAY, E. G., ARBOGAST, R. T. and PEARMAN, G. C. JR. 1971. Relative humidity : its importance in the control of stored product insects with modified atmospheric gas concentrations. *J. Stored Prod. Res.*, **6** : 325-329.
- JOHNSON, M. L. and KRITZMAN, E. 1985. Vapona for pest control in a museum, 1964-1982. *Acta zool. Fennica*, **170** : 75-76.
- LEDERER, W. H. and FERSTERHEIM, R. J. 1983. *Arsenic : industrial, biomedical, environmental perspectives* : xvi + 1-443. Van Nostrand Reinhold Co., Inc., New York.
- LINSLEY, E. G. 1946. Some ecological factors influencing the control of carpet beetles and clothes moths. *Pests*, **14**(7) : 10, 12, 14, 16, 18.
- MALLIS, A. 1964. *Handbook of pest control. The behavior, life history, and control of household pests* : 1-1148, (4th ed.). MacNair-Dorland Co., New York.
- NEGHERBON, W. O. 1959. *Handbook of toxicology, Vol. 3 Insecticides* : xxv + 1-854. W. B. Saunders Co., Philadelphia, Pennsylvania.
- PELTZ, P. and ROSSOL, M. 1983. *Safe pest control procedures for museum collections* : 1-8. Center for Occupational Hazards, New York.
- SCHOFIELD, E. K. and S. CRISAFULLI. 1980. A safer insecticide for herbarium use. *Brittonia*, **32** : 58-62.
- WILLIAMS, S. L., LAUBACH, R. and GENOWAYS, H. H. 1977. A guide to the management of Recent mammal collections. *Spec. Pubs., Carnegie Mus. Nat. Hist.*, **4** : 1-105.
- WILLIAMS, S. L., GENOWAYS, H. H. and SCHLITTER, D. A. 1985. Control of insect pests in Recent mammal collections. *Acta zool. fennica*, **170** : 71-73.
- WODSEDALEK, J. E. 1912. Life history and habits of *Trogoderma tarsale* (Melsh) a museum pest. *Ann. Ent. Soc. Am.*, **5** : 367-381.

## DISCUSSION

*Q. If all the chemicals we use as insecticides possess different side effects, in some cases adverse, do you think it is advisable to use preventive precaution only till we get chemicals with no or minimal side effects ?*

A. We do not anticipate a time will ever come when chemicals with no side effects will be available. These chemicals are designed to kill living organisms, therefore, we can expect side effects to humans. We can look forward to a time that possibly some other means of control such as biological agents may replace chemicals. However, we do not expect this to happen in the foreseeable future.

*Q. In our country there are a number of private as well as semi-Government agencies for the pest control. What do you think of shifting responsibility of pest control to these agencies in addition to the vigilance by the scientific personnel attached with collection ?*

A. Private or semi-Government agencies may be used for pest control. This removes the staff from the danger of applying these poisons. The presumption is that these professionals will have a better knowledge of the insecticides than the museum staff. However, the responsibility for the long term safety of the staff and collection still remain with those curators, in charge of the collection. They must keep themselves informed about the insecticide being used. They must then take any measure necessary to protect the staff or collection.

*Q. What is the desired distance between the pest management house and the main building ? With such a risk for the working staff do you have a life insurance done for them at your place (museum) ?*

A. The beetle colony needs to be in a structure physically separate from the collection storage area. No set distance is necessary. The museum has life insurance for staff members. However, this is part of our job benefits and not because of the dangers of insecticides.

*Q. In fumigating the collection of mammals at Carnegie Museum of Natural History, do you treat the whole collection simultaneously, or section by section ?*

A. We fumigate the entire collection at one time. We choose a time when the staff will be away from collection area during the time that the DDVP is in the cases.

- Q. In your presentation no microbiological control for insect pests are mentioned. For example Bacillus thuringiensis can effectively control caterpillars of Tineidae (Lepidoptera). These are specific for Lepidopteran insects. Such bacilli for coleopterans can also be found out and used. What is your opinion ?*
- A. Nothing such as this has ever been tried in research collections. However, we look forward to the day when biological control will replace chemical control.

## **GENERAL CONSIDERATIONS IN COMPUTERISATION OF COLLECTION DATA**

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### **INTRODUCTION**

There is little doubt that computers hold the key to success in the rapidly evolving Information Society which is replacing the Industrial Society of the early to mid Twentieth Century. With the advent of computers, new horizons are being opened, questions which take months of answer in the traditional environment of museums can now be answered in a period of minutes with the push of a button. Suddenly all a researcher ever wanted to know about a species of murid is at his fingertips, waiting for the frontiers of science to be rolled further back. This position is, of course rather idealistic and futuristic but it typifies the attitude of many museum personnel who have had only peripheral contact with computers and computerised systems. While computers do indeed offer many advantages to the museum professional, these advantages do not come easily. Computerisation of museum records is no small task and can lead to serious problems if it is undertaken without proper planning. For each successful museum project there are perhaps a hundred unsuccessful attempts. These are not good odds, but there are steps which museums can take to increase the probability of success.

Computers with all their speed and accuracy are incredibly dumb. They cannot think. They will not solve curatorial problems unless they are preconditioned (programmed) to do so. They cannot make good data out of a collection of dissimilar information. They will not save time, money, or personnel unless the reasons for and methods of implementation have been carefully defined. It is vitally important that the existing manual system is clearly understood since it will be the source of data for the new system. Furthermore, the ability of the computer to provide the services required depends entirely on the ability to clearly define what is to be done, and the framework in which it is to be done.

The basic reasons for computerisation may be simple or complex depending on the particular museum involved in the project. Larger museums tend to approach computerisation from the aspect of *ad hoc* reporting in order to fill the constant demand for information contained in their collections. Linked to this may be the desire to speed up the

curatorial effort by producing specimen labels, loan sheets, location indices, etc, from a single computerised record. Other museums may use a computer to produce cross-indices to its main catalogue similar to multiple card files, but the bulk of the data remains on the manual system. Still others may use small computers to carry out individual collections management tasks such as loan preparation.

Computerisation of collections data is not a simple decision. Does a museum with 1,000 specimens need to computerise its collection? How about 10,000 or 100,000 specimens? Where is the line or is there a line? There really is no magic number above which computerisation is feasible and below which it is not necessary. A zoological garden (zoo) may have only 1,000 specimens but it may be required to keep complex breeding or nutritional records. For this organisation a computer might be indispensable, but for the small natural history museum with good manual records and low demand for information contained in its collections records, a computer is probably not necessary.

In the age of computers where cost of machines is rapidly declining and capacities are increasing as various vendors announce new products on an almost daily basis, it is easy to get swept up in the excitement and push toward computerisation of museum records. Extreme care must be taken when computerisation is considered. Not all computer systems are what they appear to be in the four colour full page advertisements seen in almost every publication. There are procedures which should be followed in order to avoid buying a machine which is underpowered for the task at hand or overpowered for the needs of the museum.

#### GOALS AND OBJECTIVES OF THE MUSEUM

The starting point for determining whether a museum should or should not computerise its data is the goals and objectives of the museum itself. Any decision to move in this direction will have a definite budgetary impact because computerisation cannot be done without some commitment of capital. This means that moneys will either have to be raised or diverted from other areas currently being funded by the museum. Computers are not a one time expense item. They require continual attention both in terms of personnel and supplies. Computers once installed usually do not (nor should they) last for more than three years without upgrade to a larger machine or more storage capacity.

The importance of the collections and the associated data must be evaluated in light of other museum needs such as education or public programmes, routine maintenance, or, collection growth. All these items and many others comprise the total budgetary picture of the museum

and fall within a predefined order of priorities for that museum which generally reflect its goals and objectives. If the museum is functioning efficiently with manual records and the move to a computerised system cannot significantly impact these costs, it may be better for the museum to avoid computerisation. Alternately, if a museum has a heavy research component and demands for information are more than the museum can support, but it wishes to do so, computerisation may be an efficient mechanism to increase productivity without increasing staff over the long run.

The goals and objectives of the museum as a whole must be clearly understood because it is within this framework that any computerisation project must exist. The project must fit comfortably in order to enjoy continued budgetary support which it will need to be successful.

#### TYPES OF COMPUTERISATION

As alluded to above there are different types of computerisation which an institution may undertake. Each type requires different amounts of resources and fulfills different needs. The most common type is complete computerisation of the main cataloguing system. The end product of this type of system is basically reporting of data in various forms not before possible in the manual system. This not only provides differing formats but also reduces the amount of clerical time necessary to develop the reports. Additionally, there are by-products such as label production, loan processing, and location files which complement the curatorial effort. This type is not only the most common today but also the one which is most prone to failure because of the enormous amount of data involved and the time required to enter this data.

A second type of computerisation involves inventory control. In this type only a subset of the data is recorded into a computer system in order to track the movement of specimens during and after the cataloguing effort. This type of system is most used in art museums where a lengthy period of time may pass between the acquisition of the items and the time it enters the collection. In this system, items are tracked as they are moved within the museum, shipped out on loan, or sent out for repair. Generally application of inventory control does not exist in a natural history museum. Natural history museums use a subset of the catalogue information to record the location of a specimen within the collection and its status.

The third general category of computerisation involves collection management in the restricted sense. Here there are a variety of small computer programmes which may do label production, produce loan



reports or track fumigation and other historical data concerning the collection as a whole. Most of these applications do not contain detailed information on specific specimens, rather aid the collection manager in performance of routine tasks in caring for the collections in his charge. This application at this time is not well developed in most museums using computers, however, much of the work done by collection managers has potential for computerisation.

### SYSTEMS ANALYSIS

The systems analysis phase of the project is the most important segment of any computerisation project. It is this phase which demonstrates whether a computerised system is really necessary or whether the manual system can be continued with greater success. Great care must be taken to carryout the systems work in detail because any decisions made here will have repercussions throughout the remainder of the project. Basically the systems analysis is divided into three parts. The first part deals with the historical perspectives of the current system and the foundations on which it was built. The second part examines what is being done now based on the existing foundations and modifications to them through the years. The final part encompasses the expectations of the new system—the plan for what is to be accomplished.

Understanding the historical perspectives of any cataloguing system is important because the system has probably changed through the years as different curators added or deleted fields of information from the catalogue reflecting the changing demands of researchers through time. For instance, in most catalogues locality data is very general in earlier stages of the collection records, however, as the trends in systematics changed and the field of ecology blossomed the need for more specific locality data grew and the catalogues began to reflect this need. These variations within a cataloguing system are reasonably transparent to a researcher browsing through the collection records but any computerised system must take them into account if data retrieval is to be utilised to its fullest extent. The full range of data within a catalogue must be defined with all its variations in order to properly convert the data from a manual system to a computerised one. If a date is recorded in several different formats, a single standard format must be decided upon and all other formats should be converted to it at some time during the process in order to obtain maximum utility from the new system.

Understanding the current system is also important because a museum cannot define a new system without understanding the existing base of information from which the new system will be generated. There are several things that must be fully understood in this area. The data,

of course, is of primary importance when documenting the contents and function of an existing system. Each field or data element must be precisely defined in order to record the nature of the field, the format it takes (er 12 Nov 1983 or 11/12/83), the necessity of that field, the source of the data, and the uses to which that data may be put. The standardisation of the data is critical to the success of a computerised catalogue. Without standardised data, retrieval of information would be extremely difficult. Data definitions and data standards then are a key ingredient to a useful systems analysis. Data definitions refer to the uses of fields of data while the standards refer to the formats and conventions to be used in recording these data elements.

Understanding the data elements is important, however, there are other aspects of the current system which must also be understood in order to successfully conclude a systems analysis. Up to this point only the data itself has been discussed but the data are only the building blocks upon which a much larger system of documents and interrelationships are built. The data collected together obviously form the master catalogue in most cases, but there are other files and indices which require constant curatorial attention. Data are recorded in field notes, on loan sheets, in cross reference files, inventory lists, preparation lists, and a variety of other documents which are maintained or generated by the curatorial or collections management staff. All these documents are interrelated through the basic data present in the master catalogue and each of these documents must be examined closely to determine whether they should be integrated into the new system or be dropped and replaced with a computerised function. Again, the uses of the data must be considered in the decision regarding the proper definition and standard to be applied to a particular data element.

Finally, after all the review and definition, the museum should arrive at a point where a document exists which defines the current and historical nature of the data and all related documents and processes. The museum should now understand exactly how its own system was put together and what functions are currently being carried out within its curatorial areas.

The museum must now embark on the task of defining what is required from the new system. First of all, the entire range of standard reports must be defined. This would include such things as master lists, all cross reference reports, loan reports (skin and skull tags), and any other report which will be generated on a regular and ongoing basis. These reports must be laid out in detail to include the printing format, data, paper to be used, etc. Following this all requirements for *ad hoc* reporting should be defined. This would include all data elements which the

museum perceives would be necessary to service the needs of its researchers.

Once all the reports are defined in terms of data elements needed, a final set of data standards are drawn up which precisely define the format of each data element which the museum has deemed important enough to include in the reporting requirements discussed above. These data standards might not include all data which was previously recorded in the manual system or may include other elements which were not previously captured. This list of data elements and their definitions now become the basis for the new cataloguing system.

Now that all the reporting requirements and the data standards are clearly delineated, it is time to re-examine the manual system to see if it can accomplish all that the museum requires without undo difficulty or expense. Perhaps a decision to computerise should be withheld or delayed until such time as the manual system cannot handle the load. If this decision is reached, the exercise was not a waste of time, because the museum now has a documented record of its data and reporting requirements upon which any future decisions regarding collections records can be based.

If however, the decision is reached that the manual system cannot handle the requests for information either because of poor organisation of records or lack of resources, the process must continue on so that computerisation may be attempted with the greatest probability of success.

The final step in a systems analysis which leads to computerisation involves definition of the collection as a whole in terms of size, number of data elements per record and the size of each record. This is usually done by adding the total number of characters in each data element (this is defined in the data standards for each data element) to acquire the maximum length of a single specimen record. This length is then multiplied by the total number of specimens in the collection to give an approximate collection size for later use in estimating the amount of computer storage needed to hold the current collection's data. An estimate of collection growth is also important in order to plan for the future.

Computers have the ability to rearrange information and present it in a different order than entered—this is called sorting. The systems analysis must present some considerations of sorting in terms of the levels or depth of sort the computer system will be required to do. In many instances the predefined reports will illustrate this. An example of sorting depth would be this hypothetical report request which could appear on a curator's desk. "Please give me a list of all rodents from

Africa, listing each family and included species for each country” The computer sort required to do this report with one pass through the data after continent and order Rodentia has been selected, would be done in the following way :

- (1) sort by country
- (2) sort by family
- (3) sort by genus
- (4) sort by species

Although this is a fairly simple sort, many computer systems do not have the ability to sort to four levels as this example requested.

Also implied here is the ability of the computer to print out the information requested from the curator. Even though many computer systems can store the collections data and sort down many levels, there is not always an efficient mechanism for reporting that information to the user if hardcopy (printed report) is desired. A computer will be able to generate the standard reports discussed earlier because those reports will be done through a specific set of computer code called a programme. Programmes are written to generate a hardcopy report on request. These programmes take considerable time to prepare and are not easily modified. *Ad hoc* reporting, such as the request from the curator above, require a mechanism called a report writer which will generate a reasonably well formatted hardcopy report with a minimum number of commands. These report writers vary tremendously in quality and the systems analysis should contain information on the expectations of the museum for the report writer. It is usually preferable to design a few *ad hoc* reports and include them in the systems analysis so that report writers on various machines can be tested against those requests.

Basically the systems analysis is now done and the museum is ready to begin the task of seeking the proper computer to do the work defined. The systems analysis has provided the following information which can be used to compare machines and software :

- (1) List of data elements to be captured and entered into the machine. This list contains the format and size of each data element.
- (2) Exact specifications of all reports needed from the system on a regular basis.
- (3) All the functions which interact with the main catalogue and the definitions of those functions.
- (4) The size of the collection. (The total amount of storage space needed to hold the entire collection.)

- (5) The requirements for sorting depth.
- (6) The requirements for *ad hoc* reporting and the report writer.

#### ADMINISTRATIVE SUPPORT

It is now time to return to the goals and objectives of the museum. Having determined that it is worthwhile to do the systems analysis earlier, it is now time to return to the administration of the museum to present this work and explain in detail why the new system is necessary to continue to function in accordance with the goals and objectives of the museum. It is imperative that strong backing be demonstrated by administration. In all probability any system which will do what is expected from the systems analysis is going to require a significant investment. The cost parameters should be carefully discussed with administration so that a system can be designed to fit the needs of the museum within the budgetary framework established. If the systems analysis is so expensive that a machine outside of the funding range is required, it is better to go back and reduce the amount of work planned for the machine than to press ahead with a machine that is too small to successfully handle the tasks required. A machine which is too small or underpowered will lead to frustrations and probably to project abandonment within a short span of time.

If the budgetary support is present for the proper machine, do not leave the administration with the feeling that once purchased, the machine will serve needs of the museum for an extended period of time. In all probability, with proper staffing, a project will require an upgrade in computer power or storage in three years or less. Computers once put into an environment, tend to fill to capacity. The uses for them extend far beyond all the contingencies planned for in the systems analysis. Computer familiarisation generally breeds more demands for additional resources and the administration must recognise that this will occur.

However, support is acquired, it is absolutely essential to have it. Without administrative support the project will fail! A large number of projects in the United States have failed and are failing for this reason. Projects were started without proper financial backing and moved too slowly with inadequate machinery. It is better to shore up a manual system than to begin a computer project which is underfunded.

#### HARDWARE

The actual machine and its associated devices are called hardware. Generally speaking there are three classes of hardware : mainframes.

minicomputers, and microcomputers. All three of these can be and have been used in museum environments with varying degrees of success. The mainframe is the largest class of machines. These machines contain the largest memories, the best software, most versatile capabilities, and are the most expensive to purchase, operate, and maintain.

Generally speaking these machines are restricted to large computing environments such as governments, universities and hospitals. There are few museums in the world which can afford to purchase and maintain a machine of this size to handle its internal affairs. The price of these machines start at about \$500,000 and goes up with annual maintenance contracts beginning at \$5,000 per month not including specialised personnel to operate them.

It is, however, not unusual for museums to use these mainframes for collections management if it is associated with a university or has access to government computing resources. The museum may rent time and storage space on these large machines and take advantage of the power and resources available in them. With this type of arrangement, the museum does not bear any of the problems associated with operation of a computer but reaps the benefits of its use. The rental of time and space may not be prohibitive within the scope of the museum budget depending the arrangements which can be worked out with the host institution. It is generally affordable, at least in the early stages of computerisation where files and storage requirements are small.

The second class of machine is the minicomputer. This class of machine costs less than the mainframe with costs ranging between \$60,000 and \$400,000 for machines of varying capacities. The minicomputer does not have the range of software available for it that the mainframe has but does have adequate software for most applications. The memory capacity is usually sufficient to carry out museum related tasks and enough storage can be put on the machine to handle large museum data files.

Storage of data is an important consideration for a project such as catalogue computerisation. If a museum collection contains 100,000 specimens and each specimen record is 500 characters long, a total of 50,000,000 characters of storage will be required to hold the collection data. This amount of storage does not include any programming to handle the data, overhead to operate the computer (operating system), work area to formulate reports and sort records, nor any room for expansion. Depending on the software chosen, which has a direct effect on how the data is stored, a minimum of 1.5 to 2 times the amount of

storage to hold collection data will be needed to provide adequate resources and expansion space for the project. In the case of the example a storage device (called a disk drive) will have to be about 75 to 100 megabytes in capacity. A megabyte is defined as a million bytes or characters of information in machine readable form. Minicomputer capacity usually ranges in size from 50 megabytes to about 3,000 megabytes or 3 billion characters of storage.

Mainframes and minicomputers share many features in common and the difference between the two may only be one of scale or available software. One of these shared features is the ability of the machines to support multiple users doing different tasks at the same time. This timesharing feature can be extremely important if the museum plans to use a number of personnel to input data and carry on other functions simultaneously. Timesharing also has some problems which must be considered at the time a machine is purchased. The number of users and the type of work being done can directly affect the performance of the machine because each user and each task performed requires a portion of memory in which to work. In the early stages of data entry, the demands on the memory are relatively low because data entry requires more typing than processing. However, when, the files begin to be searched for information and sorted for reports, the demands for memory rise considerably causing a decrease in performance. This performance drop is usually an indication that the machine must be upgraded to a larger model or that memory and storage must be increased.

Unlike the mainframe and the minicomputer, the microcomputer is much smaller, cheaper, and does not usually support multiple tasks occurring simultaneously. The major limiting factor for most museum applications however is the amount of disk storage available on which the collection data files may be stored. While these machines may be excellent for small tasks such as loan reports, label writing, word processing, etc, they are wholly inadequate for processing the large files created from natural history collections. Typically a microcomputer contains less than 40 million characters of disk storage. This may be enough to contain cross reference files to a collection but not enough to contain the collection data itself.

Research and development moneys are being poured into the microcomputer and some startling gains in their capacities and performance have been made in the last year or two, however, they have not progressed to the point where they are relatively risk free and as useful as the larger machines. In time the microcomputer and the mini-computer will probably merge taking the best of both types of machines.

The hardware component of the museum system then must be considered carefully in terms of the definition of the project to be completed. If total catalogue entry is to be attempted, access to a mainframe or minicomputer is the preferred route at this time. If, however, a small project dealing with loan processing, labelling, etc, is contemplated, a microcomputer may be the machine which can best do the job economically.

## SOFTWARE

All of the types of machines mentioned above are nothing more than pieces of equipment with no function at all until the software is added to them. The software is the programmes or machine instructions which interpret the commands to make the machine produce a desired result. Software is the key to picking the proper computer system to perform the functions outlined in the systems analysis. Very few software products will do all of the functions designed in systems analysis but many will approach the needs of the museum.

There are several things which should be kept in mind when looking at a software package to do any job, especially handling files the size of collections. A good software package should be able to handle data files of almost any size, it should have a good report writer, be able to handle multiple levels of sorting, it should be able to store and modify stored data efficiently, and it should be relatively easy to operate. Many of these considerations were discussed earlier, but are worth repeating again because once a software and hardware system is selected, the museum must live with shortcomings as well as its benefits.

When searching for the software package to do the task defined it is always worthwhile to examine the techniques of other similar museums to see if they are applicable. Get expert advice from wherever it is available and read as much as possible about implementing software in museum situations. Do not restrict the search for software to museums however, because computerising collection data is really not that much different from inventory control, a process which has been computerised in many industries for many years. These industrial applications may be exactly what is needed and are especially useful if a mainframe computer is available. It may be possible that no system can do what is desired by the museum and the whole process or at least a good part of it must be generated by hiring an outside consulting firm to develop the programmes needed to accomplish the task. This is probably the most expensive option which is available to the museum. In the last two years there have been many general purpose programmes developed for machines of



all sizes and it is highly likely that one of these can serve as base system for computerisation of collection records. Even with a good base system, some custom programming will need to be done.

#### SUMMARY

Computerisation of collection information is not a simple task and should not be attempted without considerable planning and support. The two most important aspects of computerisation is the acquisition of administrative support and the development of a detailed systems analysis for the existing systems including an exact plan for what is to be accomplished. If these two items are successfully carried out, the selection of the hardware and the software to actually effect the plan will fall easily into place. Not all museums will have the expertise to carry out a full systems analysis needed to insulate themselves from failure. It is highly desirable to spend some funds to hire experienced individuals who are familiar with museum records as well as computer systems to aid the museum in either doing the systems analysis or training internal personnel in the techniques of doing it. The cost of doing this may vary considerably depending on the scope and complexity of the project, but it will probably be worth the expenditure in time to save frustration by museum personnel.

It should be pointed out finally that the complexity of a successful implementation is much greater than could be explored here in these few pages. There are whole areas involving implementation and documentation which were not explored here. It is suggested that the attached references be consulted in detail before embarking on any computerisation project.

#### REFERENCES

- DUDLEY, D. H., *et al.* 1979. Museum Registration Methods. (3rd ed.) : 1-437 : American Association of Museums, Washington, D.C.
- MCALLISTER, D. E., *et al.* 1978. The Complete Minicomputer Cataloging and Research System for a Museum. *Curator*, **21**(1) : 63-91.
- SARASAN, L. and NEUNER, A. M. 1983. Museum Collections and Computers : 1-292. Association of Systematics Collections, Lawrence, Kansas.

- SUTTON, J. F. and BLACK, C. C. 1975. Data in Systematics Collections. *Mus. Data Bank Res. Rep.*, **6** : 1-6.
- WILCOX, U. V 1980. Collections Management with the Computer. *Curator*, **23**(1) : 43-54.
- WILLIAMS, S. L., SMOLEN, M. J. and BRIGIDA, A. A. 1979. Documentations Standards for Automatic Data Processing in Mammalogy : 1-48. The Museum of Texas Tech University, Lubbock, Texas.

#### DISCUSSION

- Q. Unemployment being a great problem in many of the developing countries, don't you think that computerisation will further reduce the job opportunities for the museum specialist ?*
- A. Computerisation generally leads to increased employment although the type of employment may vary slightly. I hear of no case where a computer was installed in a museum causing a reduction in personnel—it really is the opposite.

Your comment reflects a common fear about computerisation. However, its been my experience that one of the added expenses that computerisation provides includes technical personnel to run the computer, as well as semi-technical and clerical positions that may be added for the data entry, proof-reading of newly entered files, etc. In my own personal experience, the computer has actually increased my own workload because it seems that the more information man can access, the greater his opportunities for utilising that information. The computer provides an information explosion, it becomes the decision of the curator how that information will be utilised.



**APPLICATION OF DOCUMENTATION STANDARDS  
AND AUTOMATIC DATA PROCESSING IN  
RECENT MAMMAL COLLECTIONS**

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INTRODUCTION

The idea of computerisation of museum collections for data management was first considered during the mid-1960s. A need for some better means of information retrieval was becoming obvious to many people who used museum collections for research (Anderson, 1963; Ellin, 1970/1971a; Squires, 1970). The potential for numerical manipulation in the computer field had already been realised for a number of years, and the development of computer technology had seen what was termed its 'third generation' by 1963 (Chenhall, 1975a). However, the electronic manipulation of words is somewhat more complex than the handling of numbers. This complexity was one hurdle that had to be overcome before museums could seriously consider computerisation of their collections. In 1965 it would have been difficult for most museums to house the large-sized equipment that would have been necessary to store and manipulate their collection data (Hall, 1972). Computer technology has rushed forward so rapidly that today it is nearly impossible to write anything specific about computers without discovering that the information is out-of-date by the time it has been printed. Innovations are literally occurring daily and many of these changes are favourable for the type of work required for both museum collection management and research purposes.

Since about 1965 various individuals associated with museum collections have pushed strongly for the computerisation of their collections. There were often serious disagreements within an institution as to the advisability of such a move (Elisseff, 1970/1971). The question of data manipulation is complicated further when trying to cross disciplinary lines and determine how one should treat objects from different collections containing both scientific and historical specimens or art objects. Individuals from different departments within a museum may not have the need to interact with each other as much as they do with colleagues from their own discipline at other museums. Thus, in general, individuals with an interest in computerisation of museum collections sought out members of their own discipline and often acted independently of other

departments in their own museum (Anderson, 1975; Chenhall, 1975b; Shetler, 1975). Task forces were set up to study the idea of producing data banks or computer networks (Ellin, 1970/1971b; Greenberger *et al.*, 1973; Vance, 1967, 1975). The idea of setting up a network seemed much more likely to justify the cost of computerisation. It was often hoped that funding could be found for such a data banking project without drawing heavily upon one's own institutional resources. Doubters within one's own museum could thus be circumvented, and doubters within one's discipline would simply miss out on the easy access to volumes of data that networking promised to provide.

In 1975, the Association of Systematics Collections' Council on Standards focused its attention on data standards for Electronic Data Processing (ASC Council, 1975). During the same year, under the auspices of the American Society of Mammalogists', a workshop was held to develop a computerised network among mammal collections, called Network for Information Retrieval in Mammalogy or NIRM (Anderson, 1976; Grotta, 1975). It sounded like a good idea, but funding was not forthcoming for the NIRM project.

Sarasan and Neuner (1983) and Peebles and Galloway (1982) report that hundreds of computerisation projects among various disciplines were in progress by the late 1970s within the United States, but they complain that many of these projects were poorly conceived and launched because computerisation was the thing to do. Most recently published information on computerisation in museum collections cautions against over-expectation (Shetler, 1974). Interestingly, many mammal collections do not appear to have ridden so unanimously into the fray as some other disciplines did. A recent survey of 360 North American institutions with mammal collections, conducted by the American Society of Mammalogists' Committee on Information Retrieval revealed that less than 30 respondents are involved in computerising their collections (McLaren, 1985). No reports were received of any project failures but lack of response from some institutions may indicate disappointment in some projects known to be in progress. Many respondents were interested in computerisation but felt they lacked the know-how to begin. These people are in the enviable position of being able to (1) learn from the mistakes of others (2) benefit from the ever-improving state of computer technology; (3) and utilise some of the positive information specific to mammal collections which grew out of the NIRM committee work, and which has been expanded since that time.

#### SYSTEMS ANALYSIS

The computer is like few other inventions devised by man. It can be used in hundreds of different applications with tremendously diverse

results. Knowledge of its capabilities has become a profession in its own right. Specific terminology has grown up around its usage and familiar words have taken on new meanings when applied to the computer.

A museum's use of the computer differs markedly from the more traditional uses found in the business world. For this reason, the most important step to be taken when considering computerisation is to educate oneself. This can be accomplished by becoming familiar with the basic terminology and reading about how the computer functions. The literature should be checked for information that has been published by others who are applying the use of computers to the museum field (Foote and Zidar, 1975; Lytle, 1967; Sarasan and Neuner, 1983). Roberts and Light (1981) have produced a comprehensive report of progress toward electronic documentation with international scope, giving capsule summaries of work in seventeen countries. The American Society of Mammalogists' Committee on Information Retrieval can provide information pertaining to computerisation projects that are underway for North American mammal collections. By discussing the matter with other computer users in the museum setting, it may be possible to gain valuable insight into the difficulties they have encountered and avoid some problems. If it is possible to arrange a visit to other collections with functional computer systems, it will be easier to visualise the type of system that may be developed at one's own institution, or find out what not to use. After visiting more than one collection, an appreciation can be gained for the different types of equipment that can be used to achieve similar ends. Whereas keypunch machines and card readers were the state of the art for generating and inputting data several years ago, Visual Display Terminals (VDTs) now perform the same function more effectively (Pankhurst, 1972). Thus, depending on when a collection began to computerise, its size, and budget, many different forms of equipment may be seen. This diversity is only the tip of the iceberg in terms of the multitude of choices and decisions to be made on the road to computerisation.

A museum collection presents unique problems for data handling. A very large data file is produced and usually plans are made to retrieve information from that file in a number of different configurations. This retrieval and sorting requires vast amounts of space that are unprecedented among business applications. Seeking the proper devices to accomplish the desired goals will probably be more successful if some working knowledge of the computer can be incorporated with one's expertise on the museum collection (Wilcox, 1980). Learning how to ask the right questions is the essential basis for building an automatic data processing system. Of course, canned programmes are available and are strongly advocated by some people (Krauss, 1973). However, if this approach is taken, an even stronger foundation of computer knowledge may be

advisable. Material is often printed to provide an overview of pre-existing generalised programming for museum collection use (Creighton *et al.*, 1973).

When considering computerisation for a collection, the staff must come to grips with some questions that seem nearly too obvious to ask. Sarasan and Neuner (1983) point out that business and industry take a methodical approach that is not often seen in museums considering this large undertaking. They suggest that the following steps should be documented in writing before any computerisation project is launched:

1. Analysis of the existing manual system ;
2. Definition of problems ;
3. Establishment of goals ;
4. Determination of steps needed to achieve these goals ;
5. Estimate of *realistic* time frame for the project ;
6. Estimate of costs ;
7. Evaluation of whether a project is worth doing given the projected time and costs.

For museum personnel, the expenditure of time involved in reaching Step 7, has apparently seemed unimportant at times. When the money becomes available and there is a feeling that computerisation would help overcome problems in data management, it has seemed most clear that one should move as quickly as possible toward typing information into the computer, and getting on with problem-solving with the assistance of the computer. This is probably one giant step towards failure because difficulties with a manual system can be magnified by the constraints that computer systems dictate. Solving problems in the midst of computerisation slows progress and throws any timetable out of the window. Recognition of collection problems does not negate the advisability of computerising but realistic assessment of problems allows for truly realistic estimates of the time it may take to computerise a collection.

Many collections that have existed for decades and which contain thousands of specimens suffer from data management difficulties that make analysis of that system a nightmare. Examining the problems with the goal of rectifying some of them may be very time consuming. However, the result of such analysis can only be healthy for the collection in the long run. Whether or not computerisation will ultimately be judged the best idea for the collection, analysis of the system will not be effort lost. It can assist in developing some good ideas about the efficiency of the present way of doing things.

Each collection has its idiosyncracies and its own goals. The staff of a particular collection has the best feeling for the use of specimens and data, and the purpose of various operations at their facility. Examination of the existing system of registration and/or cataloguing is a good starting point. One must define what data associated with each specimen are essential to management of the collection and useful for research purposes.

The fundamental problem in dealing with a manual system that may have been started a century ago is that many changes have occurred over those decades—geographic and taxonomic name changes, changes in the type of specimen preservation (Sutton and Black, 1975), and changes in curators with different philosophies and different interests. A computer works by taking human language, turning it into machine-readable language for manipulation and then changing it back to a readable form for its user. Therefore, it is usually necessary to make changes in the written word of the manual catalogue so that it conforms more easily to machine-readable data.

Each specimen carries with it a set of data. This set is referred to as the specimen record. Within each record are related groups of information such as the taxonomic and geographic data. Each of these groups can be broken down into more fundamental units which are usually called data fields or categories. It is best for later purposes of information retrieval to have well defined data fields that have been reduced to very simple units (Mello, 1974). For example, the geographic data may be subdivided into as many as five units—continent, country, state or province, district or department, and specific locality.

For the purpose of examining the data contained in a specimen record, each data field in use on the manual system or in any cross-referencing files should be placed on a list. Any categories which are not currently used but deemed desirable should be added to this list. The entire manual system need not be placed on the computer file.

By sampling 150-200 records (Sarasan and Neuner, 1983) at regular intervals throughout the collection, and listing all data under discrete categories, one can arrive at a fair approximation of the average number of characters per record. It may be helpful to tabularise the total number of characters involved in each record when deciding which data fields should be entered on the computer (Fig. 1). Then, knowing the total number of specimens in the collection, these data can be extended to determine the number of keystrokes needed to enter the entire collection onto the computer file. These statistics will contribute to the prudent determination of the data fields which should be included on the automated system. The frequency of usage versus the amount of file space required



SPECIMEN RECORD NUMBER	ORDER	FAMILY	GENUS	SPECIES	SUBSPECIES	CONTINENT	COUNTRY	STATE	COUNTY	SPECIFIC LOCALITY	PREPARATOR	COLLECTOR	NATURE OF SPECIMEN	SEX	DATE COLLECTED	PREP NUMBER	SPECIAL NUMBER	ACCESSION NUMBER	COMMENTS	TOTAL NUMBER OF CHARACTERS PER SPECIMEN RECORD
234	11	9	7	10	9	13	13	12	9	6	11	11	2	1	11	2	--	3	53	183
8672	9	7	5	7	7	13	13	7	11	42	10	10	2	1	11	4	--	5	--	164
11789	8	10	10	5	--	13	13	4	8	38	25	25	2	1	11	4	--	5	17	199
23145	10	8	5	7	--	13	6	21	--	38	10	10	2	1	11	4	--	5	--	151
45621	11	8	7	10	9	13	13	7	10	29	14	14	2	1	11	4	--	5	--	169
48676	10	11	8	8	--	6	8	9	--	12	14	14	2	1	11	4	15	5	26	164
57840	8	15	13	8	8	6	5	14	--	30	11	9	2	1	11	5	--	5	--	172
58021	11	9	9	10	--	6	8	--	--	20	12	12	3	1	11	5	--	5	20	124
65196	8	9	12	16	16	13	13	12	9	25	12	12	2	1	11	3	--	5	--	179
74977	8	9	6	9	9	4	20	10	--	9	--	--	2	1	11	--	5	5	--	109
TOTAL FIELD LENGTH	94	96	82	90	58	100	112	96	47	249	119	117	21	10	110	35	20	48	116	
AVERAGE LENGTH	9.4	9.6	8.2	9	9.6	10	11.2	10.6	9.4	24.9	11.9	11.7	2.1	1	11	3.8	10	4.8	11.6	177.8

Fig. 1.—A tabularised scheme for assessment of specimen record size. (Adapted from Sarasan and Neuner, 1983).

will be best judged for each collection individually. This information will make it possible to estimate a timetable for data entry, and provide the basis for deciding upon the size of the system required.

Particularly long data fields can be shortened by using abbreviations. One example is the system employed at Carnegie Museum of Natural History for describing the type of preservations used for each specimen, thereby avoiding the need to devote a large amount of space to descriptive information. The category is referred to as 'Nature of Specimen' (NS), and all entries are translated into a two letter code such as 'SS' for skin and skull ; 'SB' for skin, skull and body skeleton ; 'AL' for alcoholic preservations, and 'SK' for skull only. When reducing information to code like this, the efficacy of standardisation among collections within the discipline becomes more profound.

Definition of each unit or data field, the acceptable vocabulary, size limitations on each field, and acceptable sequences of entering data, or syntax, should be proposed at this point. Specimen records are set up for the computer so that each data category is assigned a certain position where the computer 'expects' to find information suitable for that category. For example, the country where a specimen was collected may always be the fifth piece of data given for each specimen. The computer may be told that this category will not exceed twenty letters in length and that it will always be alphabetic with no numeric or special symbols. Limitations to be placed on the data fields can be intelligently determined using a 150-200 specimen sample (Sarasan and Neuner, 1983) from one's own collection and the tabularised scheme. Data entry must be planned with the realisation that information retrieval is not just something that the computer does. Data must be put into the system with an understanding of the method of retrieval. Otherwise, much time will be expended on building a data bank without any means of getting the information back out. Silly as this may seem, there are (Sarasan and Neuner, 1983) numerous examples of collections that rushed forward to enter their data without paying much attention to the quality of the information being provided for the computer. Of course a computer can be programmed to salvage such a mess but the cost in money and time may be prohibitive, especially if several years have already been expended on imprudent data entry.

In the process of trying to establish a Network for Information Retrieval in Mammalogy, the NIRM Committee garnered a list (Fig. 2) of what they deemed mandatory data fields for each specimen. Further data could be added depending upon the spatial constraints of the computer system being chosen by a particular institution. These groups of selected data fields were to be used by the proposed computer network which has not come to fruition to date. It was intended that individual

institutions would use the essential fields for divulging information to other collections, and maintain the optional categories of choice for the management of one's own collection. These lists were drawn up with a great deal of thought and they provide a handy set of guidelines when analysing an existing manual system. The tabularised scheme is still a very good idea when drawing conclusions about a specific collection and when attempting to set up a timetable for data entry.

MANDATORY DATA FIELDS	SUGGESTED OPTIONAL DATA FIELDS
Institution Identifier (Museum Acronym)	Specific Collecting Locality
Catalog/Serial Number	Preparator's Name
Genus	Preparator's Field Number
Species	
Date Collected	
Continent or Country	
State or Province	
County, District or Major Island Group	
Sex	
Type of Preservation	
Ocean Sea	(if marine mammal collected in open waters)

Fig. 2.—Mandatory and selected optional data fields set for the National Network for Information Retrieval in Mammalogy.

In an effort to produce uniformity in the manner in which written language is re-written for the computer, a publication called “Documentation Standards for Automatic Data Processing in Mammalogy” (Williams *et al.* 1979) was produced. Within the publication is an extensive list of categories currently being used among computerised mammal collections (Fig. 3). A major portion of the paper is actually a data element

dictionary which discusses every category which might be recorded for a mammal specimen. Each category is defined and a format is described. Variations, omissions, and examples are provided. The material can serve as a helpful model but should not be substituted for a careful analysis of one's own system.

INSTITUTIONAL DATA

Institutional Acronym  
 Division Acronym  
 Collection Catalog Number  
 Availability Status  
 Accession Number  
 Special Number  
 Donor  
 Date Cataloged  
 Published Records  
 Type Description

GEOGRAPHICAL DATA

Continent or Country  
 State or Province  
 County, Parish, District, Department,  
     or Major Island Group  
 Specific Locality  
 Reference Point  
 Reference Point Modifier  
 Township and Range  
 Elevation  
 Ocean  
 Sea  
 Bay, Inlet, Strait, Gulf, or Channel  
 Latitude and Longitude

SPECIMEN DATA

Type of Preservation  
 Sex  
 External Measurements  
 Weight  
 Age  
 Reproductive Data  
 Ecological Notes  
 Date Collected  
 Collector  
 Collector's Number  
 Preparator  
 Preparator's Number

TAXONOMIC DATA

Order  
 Family  
 Genus  
 Species  
 Subspecies

OTHER DATA

Remarks

Fig. 3.—Data fields currently in use among various mammal collections in North America.

What are the goals of producing a computerised mammal collection ? They can be many-fold but most analysts begin by discussing the production of a catalogue. Chenhall (1975a) reminds us that cataloguing is not just a numerical registration of specimens. It is a cross-referencing system which can be based on geographic, taxonomic, or other data categories—the catalogue is a finding device. The computerised catalogue is then, possibly the ultimate finding device.

In many collections, cross-referencing indices are maintained that assist in finding taxonomic, geographic, and donor information, as well as other specimen data. Information found in the master catalogue can be cross-referenced many ways but often the work expended on multiple cards for each specimen places a limit on the number of indices which can practically be produced manually (Rensberger and Berry, 1967).

In analysing a manual system, a list of the various indices extant in the current system should be produced, even if some of these indices are not up-to-date. Determination of whether key categories perform the function for which they were originally created is important to this phase of the analysis. By analysing the way in which the various card catalogues support and supplement each other, decisions can be made about which data are pivotal to a good retrieval system. In following such a listing procedure, the basis for a data element dictionary unique to a collection is developed.

Sarasan and Neuner (1983) suggest two other steps for analysis of the manual system. All pre-printed forms, such as loan invoices and accession records, should be gathered and analysed to determine their function and users. Forms represent an extension of the collection documentation. Analysis may lead to the discovery that some of these forms closely tie in with the data fields being considered for computerisation. The final step in systems analysis involves the step-by-step listing of the manner in which collection management tasks are performed. By listing which files are accessed and which forms are used, a procedures manual can be developed. Carefully stepping through the system, a better appreciation can be gained for where the problem areas might lie. Finding bottlenecks in the system may give some insight into areas of difficulty in the data entry process. Judgement can also be more precisely made as to the impact of computerisation on the various steps of the manual system. A procedures manual often represents the first attempt to produce written rules of operation for a collection and, as such, will have long-term usefulness. If professional help is sought for programming, this procedures manual may be helpful in bringing some museum awareness to a business-oriented programmer. Systems analysis can be performed professionally and in greater detail than described here. It is likely to be expensive and its acceptability may depend largely on personalities

(Squires, 1966). The suggestions made on the preceding pages provide an invaluable opportunity for those individuals responsible for a collection to clearly understand the working of the system. The time required for such an undertaking must be weighed against the cost of having someone else do it. The most important point to be made about systems analysis is "who, how, and when", NOT "if" it will be done.

#### RETROACTIVE DATA CAPTURE

Another decision that must be made is the method by which old records are placed onto computer files. This job is called retroactive data capture, and there are numerous ways of accomplishing this task. In the process of developing the procedures manual, a useful system may become apparent for one's own collection. The two most popularly discussed methods are sometimes referred to as the single pass strategy and the multiple pass strategy. With each method in mammal collections, skin tags are usually used as the primary source of data.

A specimen is theoretically handled once under the single pass strategy, and this is its strongest point. Questions that arise regarding the data are checked against hand ledgers and original field notes or other sources of confirming information before moving on to the next specimen. Using this method, things can move very slowly, when forgotten specimen data problems resurface and must be handled.

The multiple pass strategy or modular method of data entry has become very popular. This may be due to the disappointments experienced using the all-at-once or single pass method. Problems with the former method have arisen when data entry must be curtailed for some reason and no viable results can be shown due to the time spent in problem solving. The limited amount of data which has been captured turns out to be of little use since any attempt at information retrieval accesses only a fraction of the total collection data at this point.

The modular method requires that choices be made as to the importance of various data fields. Only a selected number of categories are entered the first time through the collection. If problems exist, blanks are left to be filled later. A skeleton of essential data fields, entered for the entire collection allows the automated system to begin functioning while other categories are gradually included to add meat to the data file.

At least two problems arise with using specimen labels as the basis for retroactive data capture. First, the specimens must be handled by the

person keying the data into the computer which involves quite a slow-down as tags are turned in search of various information. The other alternative is to transfer data onto a worksheet before entry so that the data capture can be done directly from paper. While this method may be more convenient than dealing with the specimens, it offers more opportunity for human error as data are transferred from tag to paper and then again into the computer file. Secondly, only those specimens that are encountered are placed onto the computer file. If the collection is several decades old, the chances are that numerous specimens will be overlooked—those specimens which are on exhibit, on loan, removed for repair, or misplaced and forgotten for some reason.

By using handwritten ledgers or file cards rather than the specimens, the data entry process can advance without dealing directly with the specimens. This method of data capture worked very well for the Section of Mammals at Carnegie Museum of Natural History. Once all of the 'old' data were entered, taxonomically sorted masterlists were retrieved from the automated file and used to curate the entire collection. In doing so, identifications could be verified and geographic and other specimen information could be checked, as could the consistency of the syntax and vocabulary used for the computer file. This method has provided a relatively accurate, workable system while corrections are made. When inconsistencies are noted, programming allows for vocabulary lists to be generated (Fig. 4). Several different spellings for the same word can be listed with counts for each form of the word. Corrections are then made by individual record or by a general sweep through the computer file, depending on the magnitude of the required change. Taxonomic updating can be done in the same manner. Missing specimens are singled out and numerical mix-ups can be traced, using the computer retrieval system.

Using the manual ledger as the primary data source can also utilise the modular method of data entry. Choosing a minimum of categories for initial entry, as the basis for a curation or general inventory programme, output could be generated in the form of data worksheets (Sarasan, 1979). Blank data fields must be filled when contact is made with the specimens.

Whatever the method of retroactive data capture, a step-wise procedure should be set forth in writing. An on-going record of what material has been entered and by whom should also be kept. By carefully documenting procedure and progress, disruption due to interruption or change in personnel can be kept to a minimum. In addition, errors in entry procedure can be traced to the individual responsible before too large a series has been handled improperly.

12/12/83      VOCABULARY LISTING OF CAMEROON IN CM COLLECTION      PAGE 1

CAMEROON

COUNT    3243

CAMEROUN

COUNT    1266

KAMEROON

COUNT    692

KAMEROUN

COUNT    710

TOTAL COUNT    5911

Fig. 4.—Reproduction of a single page print-out of a 'vocabulary list' The various spellings of the word 'Cameroon' in the mammal computer file at Carnegie Museum of Natural History are used in this example. This information search is used when the need for corrections is suspected so that the size of the problem can be ascertained.

Before retroactive entry is undertaken, some expeditious means should be devised for transferring specimen data to the individual data fields which have been chosen. The Video Display Terminal (VDT) has made this part of the operation much easier than the old keypunching method. A screen can be developed that lists all of the data categories eventually being used on the computer file, with space for the appropriate data to be entered. If at all possible, the entire record for a specimen should fit onto a single screen, and the data categories should be laid out in a logical manner for smooth entry from the primary data source. By passively querying the typist for each discrete unit of data, the unfamiliar breakdown of information units on the screen can quickly be learned.

The specimen record entry screen used by the Section of Mammals, Carnegie Museum of Natural History, is shown in Fig. 5. The left-to-right and top-to-bottom flow of information on the screen follows the left-to-right flow of information on the handwritten ledgers in current use. When one record is submitted to the computer, the catalogue number advances by one but all other data remain the same. Only categories that have changed for the next record need to be altered, thereby reducing the



Catalog number: 58021 Order: INSECTIVORA  
 Family: SORICIDAE Genus: CROCIDURA  
 Species: FLAVESCENS Subspecies: \_\_\_\_\_  
 Sex: M Continent: AF Country: CAMEROON  
 State: \_\_\_\_\_ County: \_\_\_\_\_  
 Specific Location: 4 KM S, 2 KM E PSEKA  
 \_\_\_\_\_  
 Altitude: \_\_\_\_\_ Latitude/Longitude: 03 36N, 10 48E  
 Date Collected (DD MMM YYYY): 15 AUG 1978 Nature: \_\_\_\_\_  
 Collector: ROBBINS, L W  
 Preparator: ROBBINS, L W Prep Number: 10074  
 Spe Number: \_\_\_\_\_ Accession Number: 30379  
 Ocean: \_\_\_\_\_ Sea: \_\_\_\_\_  
 Bay or Inlet: \_\_\_\_\_ Availability Status: \_\_\_\_\_  
 Loan Number: \_\_\_\_\_ Date Loaned (DD MMM YYYY): \_\_\_\_\_  
 On Loan To: \_\_\_\_\_  
 Comments: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

A: (Added by whom)  
 M: (Most recent change by whom)

Fig. 5.—Specimen Record Entry Screen in use by the Section of Mammals, Carnegie Museum of Natural History.

amount of information which must be re-submitted in subsequent records. In other words, if the genus of record '1' is *Pteropus*, that name remains in place when the catalogue number changes to '2'. If specimen '2' is also *Pteropus*, the word does not have to be re-written. If specimen '3' is *Hipposideros*, the typist will type over top of the word *Pteropus* with *Hipposideros*, and this new genus name will be recorded for record '3' and carried along to record '4'. All categories are handled this way, which can make data entry very rapid. Care must be taken to avoid improperly carrying data from one record to the next.

All data fields which may be used to the system should be included when programming is first undertaken since addition of further categories into the working system may be difficult and, therefore, costly. Careful planning cannot be overstressed.

### COMPUTER INFORMATION MANAGEMENT

Early discussion of computer use for information retrieval in museum collections usually focused on research aspects, and since much attention was given to networking, this is understandable. However, the collection management aspects are of equal, if not greater, potential. While Sarasan and Neuner (1983) remain extremely skeptical of the existence of functional information retrieval systems, the system at Carnegie Museum does work and can be queried for every field on file or combinations of those fields. This makes it possible to produce a catalogue of all specimens from any collector or preparator, to search for a particular preparator's numbers, or for specimens involved in mix-ups, to search for all specimens collected before 1900; to discover what percentage of the collection is made up of Rodentia, or to produce a catalogue of type specimens (Manning, 1969). The possibilities seem limitless, and in terms of collection management potential, the computer has proven itself a powerful assistant.

For the purpose of organised data output, the data displayed on the Video Display Terminal can be rearranged in many ways. One way to display a masterlist of all file data is to group the information into related categories, as shown in Fig. 6. Since several of the data fields shown here have collection management functions only, some categories are suppressed when supplying data to answer outside inquiries regarding the collection (Fig. 6). It is also sometimes desirable to produce output suitable for research within the collection. By suppressing redundant taxonomic and locality information, a simple data sheet can be produced (Fig. 7).

Some of the older handwritten catalogues in use by the Section of Mammals, at Carnegie Museum of Natural History do not contain all of the data fields which the current manual and automated system utilise. Categories that have been added include order, family, and continent. This has proven helpful for collection management and for answering

MASTERLIST FORMAT					
44263	OR: CHIROPTERA	COUNTRY: JAMAICA	PREP: GENOWAYS, H H	PREP NO: 3288	
	FM: MORMOOPIDAE	STATE:	COLL: BAKER, R J AND GENOWAYS, H H		
	GN: PTERONOTUS	COUNTY: ST CATHERINE PAR	DATE: 29 JUL 1977	SP NO:	
	SP: QUADRIDENS		NS: AL		
	SS: FULIGINOSUS	SP. LOC: ST CLAIR CAVE	SEX: F	ACC NO: 28513	
COMMENTS:					
42943	OR: CHIROPTERA	COUNTRY: ARGENTINA	PREP: MARES, M A	PREP NO: 3005	
	FM: VESPERTILIONIDAE	STATE: SALTA	COLL: MARES, M A		
	GN: MYOTIS	COUNTY: ORAN DEPT	DATE: 03 SEP 1976	SP NO:	
	SP: NIGRICANS		NS: SS		
	SS:	SP. LOC: 15 KM S ORAN	SEX: M	ACC NO: 29477	
COMMENTS:					
MODIFIED MASTERLIST FORMAT					
44263	OR: CHIROPTERA	COUNTRY: JAMAICA			
	FM: MORMOOPIDAE	STATE:			
	GN: PTERONOTUS	COUNTY: ST CATHERINE PAR	DATE: 29 JUL 1977		
	SP: QUADRIDENS		NS: AL		
	SS: FULIGINOSUS	SP. LOC: ST CLAIR CAVE	SEX: F		
42943	OR: CHIROPTERA	COUNTRY: ARGENTINA			
	FM: VESPERTILIONIDAE	STATE: SALTA			
	GN: MYOTIS	COUNTY: ORAN DEPT	DATE: 03 SEP 1976		
	SP: NIGRICANS		NS: SS		
	SS:	SP. LOC: 15 KM S ORAN	SEX: M		

Fig. 6.—Examples of the Masterlist format used for collection management, and the modified Masterlist, used for answering outside inquiries regarding specimens in the Section of Mammals, Carnegie Museum of Natural History.

10/14/84 PRIMATES AT CARNEGIE MUSEUM OF NATURAL HISTORY

ATELES PANISCUS CHAMEK																			
BOLIVIA DEPT SANTA CRUZ RIO YAPACANI																			
CM	2772	F	SS	22	AUG	1913	STEINBACH, J	556											
CM	2773	F	SB	23	AUG	1913	STEINBACH, J	557											
CM	2774	M	SS	23	AUG	1913	STEINBACH, J	558											
CM	2775	F	SB	26	AUG	1913	STEINBACH, J	559											

ATELES PANISCUS PANISCUS																			
SURINAME NICKERIE KAYSERBERG AIRSTRIIP																			
CM	68450	F	SK	03	MAY	1980	GROEN, J A	2075											
CM	68451	M	SK	03	MAY	1980	WILLIAMS, S L	5203											

Fig. 7.—Reproduction of computerised collection information formatted for use as a data sheet.

outside inquiries. If it were desirable to know what African squirrel skeletons are contained in the collection, the computer file would be queried to generate a list of only the African sciurids for which complete skeletons have been preserved.

Although the addition of orders and families was done directly from worksheets at the time of initial data entry, continental designations were placed on file using a 'global' change or addition feature within the programming system. With the global addition, the computer would, for example, be instructed to search for all instances where 'Cameroon' was listed under 'country'. As each record of a specimen collected in Cameroon was encountered, the designation for 'Africa' would automatically be placed under the continent data field. This method avoids human error in the form of misspellings on individual records, and misinformation which can occur using the previously described manner of expanding the taxonomic categories. It does not, however, utilise automatic data processing to its fullest potential since each country was handled on an individual basis.

As noted by Sarasan and Neuner (1983), if genus and species names are entered initially, programming can be done to allow a computerised sweep through the files for the production of additional taxonomic hierarchy. Using this method, the computer is provided with a table of taxonomic names and their hierarchical relationships. Every genus name encountered on the master file elicits a search of the table for the proper order and family names. These are, then, automatically entered into the proper data fields for that specimen record. The emphasis here is that somethings can be done extremely efficiently by computers that are not done as quickly, easily, or accurately by human beings. The converse is also true.

Becoming educated about computers and extensively evaluating a collection with computerisation in mind will aid in assessing which tasks are best done by man or machine. Just as a supervisor assigns one individual over another to a particular task, based on his talents, the 'talents' of a computer system must also be learned, in order to be used to its fullest potential. Although Sarasan and Neuner's suggestion for taxonomic expansion may work for some collections, those that contain numerous synonymies may prove to be an extremely complex programming problem. This is a prime example of the way in which a curator's intimate knowledge of his collection, combined with a basic understanding of the workings of a computer system could save time and money in the long run.

#### OTHER COMPUTER USES

The use of available computer space for bibliographic file production is another possible function of the electronic data processing system.

Although not directly linked to the collection file, it does directly support research activities and may have a more realistic networking future than the computerisation of collections.

There are some other possible uses of the computer within museum collections which are peripheral, but directly related to the collection itself. Vance and IBM corporation (1973) discuss some of these other possible uses for the computer within the museum setting which may be persuasive in the argument about whether to computerise or not. It may actually be the functions of the business office, museum membership office, public education department, and museum related bookstore or gift shop that create the impetus for acquisition of a computer within an institution (Freundlich, 1966). It may become necessary from the point of view of the business office to place collections onto the system based on insurance needs for inventory control. In this way, the accessioning process and specimen loans gain a position in the programming. This is one way of backing into the computerisation business. Unfortunately it does not take into account the tremendous need for planning the complex project of computerising a museum collection, to say nothing of an institution-wide undertaking of this nature.

At Carnegie Museum of Natural History, not every department has computerised its collections. Therefore a master file of accessions is not currently in place. However, individually computerised departments do have the capability of producing their own master accession lists, because "accession number" represents a data category which has been included for each specimen record. The possibility of drawing these data into a central file does exist, if desired, in the future.

Planning has also been initiated for computerised loan control. Several programmes have been devised to tie into the main mammal collection data file for direct application to specimens on loan. First, there is a loan invoice (Fig. 8), formatted in three slightly different ways. One copy is produced for our files, one copy is produced for the files of the institution receiving the loan, and the third copy is used for shipment and acknowledging receipt of the shipment.

At the same time that catalogue numbers of the various specimens to be loaned are entered onto the computerised invoice, the numbers will also be entered on three other files. One of these is called the Specimen Record Maintenance File. This is identical in appearance to the Specimen Record Entry Screen (Fig. 5) but it appears whenever a previously entered specimen is recalled to the screen. Each time the record of a specimen on loan is queried, it will be noted that the specimen is out on loan and when it is slated for return (Fig. 9). A second file, called the Specimen History File, will keep a perpetual tally of the various institutions to which

Page 1 of 2

CARNEGIE MUSEUM LOAN RECORD

(Please sign and return this copy when  
the loan items have been received and checked.)

From: Section of  
Carnegie Museum of Natural History  
4400 Forbes Avenue.  
Pittsburgh, Pennsylvania 15213 U.S.A.

Phone no.: (412)

To:

Attn:  
Loan no:  
Type of transaction:  
Authorized by:  
Insured by:  
Method of shipment:

Date:  
Value:  
Duration:

-----  
Description of items:

CM no.                      Comments

-----  
Condition of loan: \_\_\_\_\_  
Signature: \_\_\_\_\_ Date: \_\_\_\_\_  
-----

Date returned to CM Section:                      .Signature:

Comments: .  
Place form in active loan file.

Fig. 8.—Carnegie Museum Loan Record Invoice generated by computer.

Catalog number: 58021 Order: \_\_\_\_\_  
 Family: SORICIDAE Genus: \_\_\_\_\_  
 Species: FLAVESCENS Subspecies: \_\_\_\_\_  
 Sex: M Continent: AF Country: CAMEROON  
 State: \_\_\_\_\_ County: \_\_\_\_\_  
 Specific Location: 4 KM S, 2 KM E ESEKA  
 \_\_\_\_\_  
 Altitude: \_\_\_\_\_ Latitude/Longitude: 03 36N, 10 48E  
 Date Collected (DD MMM YYYY): 15 AUG 1978 Nature: SA  
 Collector: ROBBINS, L W  
 Preparator: ROBBINS, L W Prep Number: 10074  
 Spe Number: \_\_\_\_\_ Accession Number: 30379  
 Ocean: \_\_\_\_\_ Sea: \_\_\_\_\_  
 Bay or Inlet: \_\_\_\_\_ Availability Status: \_\_\_\_\_  
 Loan Number: X-1984-5 Date Loaned (DD MMM YYYY): 10 JAN 1984  
 On Loan TO: TEXAS TECH UNIVERSITY  
 Comments: \_\_\_\_\_ A: (Added by whom)  
 \_\_\_\_\_ M: (Most recent change by whom)  
 \_\_\_\_\_

Fig. 9.—Specimen Record Maintenance Screen with loan notation, used by Section of Mammals, Carnegie Museum of natural History.



a particular specimen has been loaned, and for how long. The third loan-related file will be an internal reminder about the duration of each loan. That way, inquiries can be made if a loan has not been returned within the agreed upon period of time.

Using the master file, labels for skeletal material can also be computer generated. An example of the type of labels used at Carnegie Museum of Natural History appears in Fig. 10. Letter quality printing of these labels is most desirable. For the purpose of fitting the labels into small skull vials, it may be necessary to reduce the size of the original computer output.

CARNEGIE MUSEUM OF NATURAL HISTORY SECTION OF MAMMALS 1297 T		!	CARNEGIE MUSEUM OF NATURAL HISTORY SECTION OF MAMMALS 1938 T	
PEROMYSCUS POLIONOTUS ALBIFRONS FLORIDA: WALTON CO; WHITFIELD			SCIURUS LANGSDORFII STEINBACH BOLIVIA: SANTA CRUZ: SANTA CRUZ DE LA SIERRA	
TODD, W E C 124	F/SS 17 APR 1903	!	STEINBACH, J 358	F/SS 14 JUL 1909
CARNEGIE MUSEUM OF NATURAL HISTORY SECTION OF MAMMALS 3415 T		!	CARNEGIE MUSEUM OF NATURAL HISTORY SECTION OF MAMMALS 3430 T	
STENOCEPHALEMYS ALBOCAUDATA ETHIOPIA: ARUSI: CHILALO MTS, INYALA CAMP			ARVICANTHIS ABYSSINICUS BLICKI ETHIOPIA: ARUSI: HORA MTS BASE CAMP, SOUTH CHILALO MTS	
RAFFERTY, D G 11	M/SS 18 FEB 1912	!	RAFFERTY, D G 26	M/SS 28 FEB 1912

Fig. 10.—Examples of the skeletal label format used by the Section of Mammals, Carnegie Museum of Natural History. This label will be reduced in size for inclusion inside skull vials.

Other types of information can also be generated using the master file but primary data sources such as skin tags should always be retained. Data generated by the computer should be considered a supplement not a replacement for such information. Because of the computer, information need not be arduously transferred by hand time and again, but verification of identifications and other data should still remain the domain of each individual researcher (Cameron, 1970/1971). Those who fear automation can be assured that the computer may be helpful in deciding that a new species has been found, but the opportunity to name it will always be the privilege of the researcher.

In summary, it should be stressed that education and planning with regard to a computerisation project are essential. The computer can be a time-saving instrument, but new tasks will replace old ones, and in the end, computerisation will not make the day any shorter. It can make an ever-growing collection manageable, and help to meet the needs of the information explosion which computers everywhere appear to be precipitating. The future of computers in general may be limited only to human ingenuity but applied to a specific system this can be an expensive premise on which to proceed. When dealing with one's own collection, it is best not to overestimate the computer. The computer will need you every step of the way.

### SUMMARY

The idea of using computers in the museum setting was first considered in the mid-1960s. The cost-effectiveness of computerisations is still strongly argued by many individuals from large and small collections alike. There are currently less than three dozen North American museums computerising their mammal collections. However, the ability of the computer to process large quantities of data in extremely short periods of time could revolutionise both the handling and scientific use of museum specimens.

A network linking many collections was the focus of much early attention on the subject of computerisation in mammal collections. Because of the consideration given to such an idea, some very careful ground work was laid for determining which categories of data ought to be recorded on computer files. Under the auspices of the American Society of Mammalogists' Committee on Information Retrieval, a set of Documentation Standards has been published. The computerisation of collection data necessitates a close examination of the precision with which previous information has been recorded for the specimens in one's collection. Whether automatic data processing is eventually undertaken or not, this type of scrutiny, with an eye for standardisation, can have a healthy effect on a collection.

Among the specimen data categories discussed are some which are considered to be mandatory if any sort of network were to work successfully. These mandatory categories include museum acronym ; collection catalogue number ; genus ; species ; date collected ; sex ; type of preservation ; country or continent ; state or province county, parish, district, department or major island group ; or appropriate marine equivalents, if marine mammals are taken in open waters. There are several other categories which can be useful for working within one's own collection including specific locality, preparator's name and field number. The

addition of several other taxonomic levels can also be helpful. These optional categories are discussed in detail.

Once specimen records have been entered, numerous peripheral tasks can also be executed using the computer. Those to be discussed include the processing of loan records, production of loan invoices, accession records, inventory of materials for insurance purposes, the up-dating of taxonomic information and changing of geo-political names, curation, responding to requests for information regarding the collection, statistical analysis and research.

The computer can be a useful tool but should not be accepted on the basis of replacement for other curatorial procedures. Its output should also not be used to replace the direct examination of specimens for research. Its use from one collection to another will vary because institutions are as unique as the specimens they house. Implementation of a computer system must conform to the idiosyncracies of the collection which it is intended to serve. Possible approaches to this task are discussed.

#### REFERENCES

- ANDERSON, S. 1963. Problems in the retrieval of information of natural history museums. In : *Conference on Data Acquisition and Processing in Biology and Medicine* : 55-57. Pergammon Press, New York.
- ANDERSON, S. 1975. Discipline-oriented implementation of electronic data processing : The specimen approach. In : *Systematics '75* : 35-36. Edwards S. and Grotta L. (Eds.). Association of Systematic Collections and Publications., Lawrence, Kansas.
- ANDERSON, S. (Ed.) 1976. Techniques and equipment to implement the National Network for Information Retrieval in Mammalogy. *Proceedings of the September Seminar on N.I.R.M.* : 1-59. American Society of Mammalogist.
- ASC COUNCIL. 1975. Report of the ASC Council on Standards for Systematics Collections. *Assoc. Syst. Colln. Newsl.*, 3(3) : 1-4.
- CAMERON, D. 1970/71 Museums, systems, and computers. *Museum*, 23 : 14-17.
- CHENHALL, R. 1975a. *Museum cataloging in the computer age* : viii+1-261. American Association for State and Local History.

- CHENHALL, R. 1975*b*. Institutional implementation of electronic data processing. In : *Systematics '75* : 32-33. Edwards, S. and Grotta, L. (eds.). Association of Systematic Collections Publications, Lawrence, Kansas.
- CREIGHTON, R., PACKARD, P. and LINN, H. 1973. SELGEM retrieval : A general description. *Cuad. Hist. Econ. Cataluna*, **9** : 173-214.
- ELISSEFF, V. 1970/71. Museums and computers. *Museum*, **23** : 4-6.
- ELLIN, E. 1970/71*a*. Computer horizons in the museum world. *Museum*, **23** : 8-10.
- ELLIN, E. 1970/71*b*. Considerations in the formation of museum data banks in the United States of America. *Museum*, **23** : 20-21.
- FOOTE, R. and ZIDAR, J. 1975. A preliminary annotated bibliography of information handling activities in biology. *J. Wash. Acad. Sci.*, **65** : 19-32.
- FREUNDLICH, A. 1966. Museum registration by computer. *Mus. News*, **44**(6) : 18-20.
- GREENBERGER, M., ARONOFSKY, J., MCKENNY, L. and MASSEY, W. 1973. Computer and information networks. *Science*, **182** : 29-35.
- GROTTA, L. 1975. ASM plans NIRM : National Network for Information Retrieval in Mammalogy. *Assoc. Syst. Colln. Newsl.*, **3**(4) : 6-7.
- HALL, A. 1972. Computer-based data banking for taxonomic collections. *Taxon*, **21** : 13-25.
- KRAUSS, H. 1973. The use of generalized information processing systems in the biological sciences. *Taxon*, **22** : 2-18.
- LYTLE, D. 1967. Where to learn about new data processing systems. *Mus. News*, **46**(3) : 32-35.
- MANNING, O. 1969. A computer-generated catalog of types : A by-product of data processing in museums. *Curator*, **12** : 134-138.
- MELLO, J. 1973. Computer revolution in systematics. *Taxon*, **23** : 21-22.
- MCLAREN, S. B. (Chairman). 1985. *Survey report on computerized information retrieval in mammal collections of North America* :

1-22. Committee on Information Retrieval, American Society of mammalogists.

PANKHURST, R. 1972. A method of data capture. *Taxon*, **21** : 549-558.

PEEBLES, C. and GALLOWAY, P. 1982. Notes from underground : Archeological data management from excavation to curation. *Curator*, **24**(4) : 225-251.

RENSBERGER, J. and BERRY, W. 1967. An automated system for retrieval of museum data. *Curator*, **10** : 297-317.

ROBERTS, D. A. and LIGHT, R. 1981 Progress in documentation. *J. Docum.*, **36**(1) 42-84.

SARASAN, L. 1979. An economical approach to computerization. *Mus. News*, **57**(4) : 61-64.

SARASAN, L. and NEUNER, A. 1983. *Museum collections and computers* : iii+1-292. Association of Systematic Collections Publications. Lawrence, Kansas.

SHETLER, S. 1974. Demythologizing biological data banking. *Taxon*., **23**(1) : 71-100.

SHETLER, S. 1975. Discipline-oriented implementation of electronic data processing : The taxon approach. In : *Systematics '75* 34-35. Edwards, S. and Grotta, L. (Eds.). Association of Systematic Collections Publications, Lawrence, Kansas.

SQUIRES, D. 1966. Data processing and museum collections : A problem for the present. *Curator*, **9** : 216-277.

SQUIRES, D. 1970. An information storage and retrieval system for biological and geological data. *Curator*, **13**:43-62.

SUTTON, J. and BLACK, C. 1975. Data in systematics collections. *Mus. Data Bank Res. Rep.*, **6** : 1-6.

VANCE, D. 1967. New ways of keeping and finding information. *Mus. News.*, **46**(3) : 29-32.

VANCE, D., IBM CORPORATION and CORSON, C. 1973. *Computers in the museum* : ii+1-69. IBM Corporation, White Plains, New York.

- VANCE, D. 1975. *Manual for museum computer network data preparation* : 1-76. Spectra Publications, State University of New York, Stony Brook, New York.
- WILCOX, U. 1980. Collection management with the computer. *Curator*, 23(1) : 43-54.
- WILLIAMS, S., SMOLEN, M. and BRIGIDA, A. 1979. *Documentation standards for automatic data processing in mammalogy* : 1-48. The Museum of Texas Tech University, Lubbock, Texas.

#### DISCUSSION

- Q. *Many mammal collections outside of North America have systems of cataloguing where individual specimens are numbered based on specimens collected each day regardless of species or number collected. Can such a system be accommodated in a computerised collection or would a renumbering of specimens using a system of increasing numbers such as the one promoted by Wilson in an earlier paper be necessary ?*
- A. Because of the wide ranging capability of computers, I feel quite certain that a means of cleverly handling the circumstances you suggest can be devised. I think, that computerisation can be made to fit each collection's unique needs and, therefore, a blanket solution may not be desirable. One must weigh the importance of standardisation of documentation, the idiosyncracies of a collection and the cost of bringing data into compliance with the Standards. Catalogue numbers are probably one of the more flexible categories, and computerisation would certainly facilitate a search through a complex numbering system.



## **ARMS, AMMUNITION AND ANIMALS—THEIR RELATIONSHIP**

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### **INTRODUCTION**

In an era when nearly all the nations have been convinced about the importance of conservation on animals and have already imposed prohibition on shooting, it may appear paradoxical to select the present theme and its title, and as the scribe happened to be a scientist intimately involved with the conservation of wild animals for nearly three decades the animal lovers may even brand it as an act of sacrilege. The purpose of this article is to highlight the utility of ballistics for the specific purpose of scientific study and museum display—the main concern here is for the collection of animals for scientific study.

Firearms are still considered the essential and integral gear for collection of animals particularly mammalian species. Although there has been a radical change in the approach to this problem, but, by and large, ballistics are still being extensively used in major part of the world, particularly in underdeveloped countries where sophisticated equipment or alternatives are still not available.

### **EVOLUTION OF FIREARMS**

It is interesting to review the evolution of firearms during the last few centuries. The revolutionary changes in ballistic have been so fast and varied that latest weapons which are much admired, appreciated and adopted may within a short period become obsolete.

Muzzle-loading firearms of old age to the present day breach loading sophisticated weapons has been a long journey. As early as 1550, smooth bores were being rifled. By 1750, a variety of innovation and developments had taken place. By 1835, Manton of England brought out 8 bore percussion lock SB rifle. In 1840 Dickson presented a novelty—the double barrel two grooved rifle, in addition to the .577 cal percussion lock DB rifle by Cogswell and Harrison. All these weapons were of muzzle loading category.

The year 1850 is an important land mark when John Rigby introduced breach loading firearms—a pin fire D.B. underlever hammer



rifle. Since 1930 there had been a steady and remarkable development. Holland and Holland did away with the hammer and introduced .500 cal hammerless DBBL rifle, so also .470 cordite DBBL hammerless rifle by Atkins of Purdey.

Today's the most extensively used rifles are repeating bolt-action either semiautomatic or manual. The existing DBBL rifles for which cartridges are available in India are classic weapons. Among the S.B.B.L. Rifles there are .458 cal magnum preferably with muzzle break, and .375 cal magnum, .30/06 cal rifle, .300 cal magnum, .270 cal rifle, etc. And for medium and small games .22 cal rifle, .220 swift, or .222 cal rifle. The modern age singles are strong enough and easily taken apart.

All shotguns are smooth bores by definition. The present shotguns are of different gauges—commonly 10, 12, 16, 20, 28 gauges, etc. The popular brand of .410 shotgun does not suggest the gauge but the calibre measured in mm. In the early days of muzzle loading weapons there was no standard in gauge, but the hunter used to pour gun powder and shots at his own sweet will. The term gauge denotes the number of balls made out of one pound of solid lead.

Since the last century shotgun ballistics had undergone radical changes. Diverse types of shortshells and projectiles were recommended for different kind of birds and mammals. Although shot shells are made in various lengths—2" 2½" 2¾" and 3"—the standard one in UK is 2½", whereas 2¾" shells are popular in America and other countries.

#### MODERN ARMS VIS-A-VIS ANIMALS

The modern weapon is already a complex contraption the employment of which has further been complicated by the even more abstract question of ammunition. In the early days it was simpler when the variation in the form and composition of big game cartridges were relatively limited. There were only soft and solid nose bullets. Basically they have not changed a great deal, though the Germans and the Americans have developed a variety in its shape and performance, the British arm makers have remained more conservative.

While on a mission for collecting large and dangerous animals, it is prudent to restrict the types of cartridges to be used and even to select a rifle which is not only powerful enough but takes popular and readily available fresh cartridges. It is not only judicious but essential to match the bullet to the type of game against which the weapon is to be used. For a large mammal the weapon has to be an especially powerful one. The superiority of the specially powerful weapon over other weapons

is determined primarily on the principle of its construction, in its special power and in the specific methods of its employment. Until a few years ago the heavy express rifles denoted the DB .600, .500, .577, .470, .465, .400/450, etc, while the medium calibre weapons were single barrel magazines. With the introduction of .458 cal magnum, although it is a single barrel, it has superseded the other high velocity rifles and is now being widely used in Africa as well as in India for heavy, thick and thin skinned mammals. Incidentally, it may be mentioned that in the heyday of big game hunting in Africa, the famous professional hunter, the late W. D. M. Bell had used .275 Mauser quite successfully on elephants although it was supposed to be too light for such animals. But his phenomenal success was chiefly due to his extraordinary marksmanship and profound knowledge of the animal's anatomy. And when all points are considered it is wise to pile up the odds in favour of the hunter/collector and at any cost the charging ferocious animal should be met with the utmost stopping power.

Quality is most vital in big game weapons. A collector for large mammals needs the highest possible quality, i.e. the calibre of Magnum group. The magazine rifles have a more complicated mechanism than that of the doubles. The entire mechanism must work swiftly, accurately, and flawlessly. In actual field conditions where the collector is standing face to face with the big dangerous game, a defect in functioning can lead to a fatal accident. British gunsmiths such as Rigby, Holland, Purdey, etc., were the pioneer producers of double barrel reliable rifles exclusively meant for big game. The existing doubles for which cartridges are still available are really classic weapons. Yet many of these rifles are of no use at present for non-availability of the cartridges and being replaced by the ever developing magazine rifles most of which are truly dependable. In the recent past over-under double rifles have been developed mostly in continental countries, and have the advantages of a single sighting plane and vertical flip.

Once  $9.3 \times 62$  (.366) rifle was acclaimed the best medium bore weapon right from elephant to antelope. It had 285 gr. bullet with soft and solid nose. It was followed by the widely popular .375 magnum, and some British bolt action rifles like .404, .416, .425, etc. In doubles there were .375, .400/450, .465, .470, .500, etc. Unfortunately due to non-production of cartridges many of them are obsolete now. It may be mentioned that double barrel rifle, though heavy, has its advantage. It is short, well balanced, and having a low line of sight, can be pointed very accurately. Above all, double is the rifle made for two shots in quick succession, which bolt action cannot render. Today's most extensively used game weapons are repeating bolt action rifles either semi-automatic or manual. Author's personal choice goes for .458 magnum with 500 gr. or 510 gr. bullets both soft and hard. It has almost the same

ballistic as that of .470 double but with an added facility of flatter trajectory. It is superb for hunting big games like elephant, rhinoceros, bison, buffalo, etc. In addition, .400/450 cal DBBL, .470 cal DBBL, .465 cal DBBL, .378 cal DBBL or .375 cal magnum are very good for deep penetration of thick skinned large mammals. However, solid bullets are required for such animals. Again, for the heavy soft skinned dangerous mammals like lion, tiger, leopard, bear, etc., the same .458 magnum, .400/450 DBBL, .465 DBBL or .375 magnum have the maximum knockout capacity. Bullets should be only soft-nosed. Even for heavy nondangerous mammals like sambar, blue bull, barasingha, etc., the same firearms with softnosed bullets are good enough.

The deer/antelope family vary in size, habit and vitality apart from being available in different topography of land. Hence, the term 'deer rifle' covers a lot of range and needs personal choice. For deer and antelope, especially in deep forest, a short rifle with fairly heavy bullet of moderate velocity serves better. They are .315, .30/06, .30/30, .275, .220 swift, .270, etc. The author's preference is for .30/06 cal single rifle.

For mountain game, there is a wide choice. However, a light well balanced 21" barrel .270 single rifle with one well-fitted 3x scope will be the best answer. Apart, there are .280, .308 and .30/06 rifles all of which have a flat trajectory. A sling is a must while shooting on the mountains.

For medium to small mammals, selection should be made from .222 Remington, .243 Winchester, .22 magnum and .22 L.R. with a variety of cartridges. Recent introduction of 'Stinger' American brand of cartridges offer more flat trajectory than the conventional ordinary .22 bullets.

#### MODERN AMMUNITION VIS-A-VIS ANIMALS

The bullets for a modern sporting rifle can be basically classified as follows

- 1 Light and fast bullets for vermin.
2. Bullets that expand rapidly and reliably on small and medium games such as deer, antelope, etc.
3. Bullets that are reliable for deep penetration on heavy non dangerous animals such as antelopes, mountain sheep and goats, sambar, blue bull, etc.

4. Bullets for heavy soft skinned dangerous mammals like lion, tiger, leopard, bear, etc.
5. Nonexpanding metal jacket or solid heavy bullets for deep penetration on games like elephant, rhinoceros, bison, buffalo, etc.

The cartridges are categorised in three classes : Rimfire, Centerfire and Shotshells. In rimfire bullets the primer is sealed in the rim, in centerfire the primer is sealed in the centre in a brass case. And shot shell includes all cartridges that contain 'shot' (tiny pellets), instead of a single projectile like rifle. The problem of manufacturing game bullets which will make everyone happy, perform reasonably well on each variety of game and at different ranges, is a difficult task and the answer is yet to be found.

The simplest type of bullet is the plain one of lead, slightly alloyed, such as .22 bullet used on small mammals and vermin. Bullets for medium and large soft skinned animals have plenty of lead core exposed at the nose and encased in a bit hard metal. The full metal jacket or solids are exclusively used on thick skinned animals. Most high velocity bullets are made with sharp points just to retain the velocity better and flatter. Some are called 'Boat Tail' or 'Taper Heel' for easy stabilisation on extremely long range accuracy. Best bullets are designed for controlled expansion and not for blowing up in pieces. Good solid bullet does not change its shape when extracted from animal's body except marks of riflings all over the projectile. There are a variety of bullets available for sporting firearms. Nevertheless it is for the collector to select the exact bullet for the right animal.

#### *Placement of shot*

Though brain shot is the most effective one, it is intentionally avoided during collecting for scientific purpose. Next comes heart shot or lung shot in the shoulder area. The lung area presents the largest target. It is preferable to use extremely high calibre bullets that will knock down and disable the animal even when poorly placed. Skull and skeleton of the specimen collected are useful for scientific study. Their minimum damage has to be assured while shooting.

#### *Use of scopes*

All scopes gather light, hence it is possible to take accurate shot under condition when iron sights would be useless. In addition, the brightness often enables the hunter to see through bush and pick out the

exact vital point of an animal. A 4X scope is excellent for big game shooting in the plains while 2 $\frac{3}{4}$  or 3X is ideal for hunting in the mountain.

### *Epilogue*

For scientific collection of medium-small to small mammals the role of firearm has almost given way to traps and nets. Moreover, firearm has its limitation, one has to have a look at the animal before shooting and this procedure has its pit falls—right from losing a sought-after species to gunning down an unwanted one. Moreover there are a variety of animals that escape notice or are too quick for shots.

In a subcontinent like India with different forest types, climate zones and altitude ranging from sea level to high snow covered mountains with myriad of mammalian fauna, selection of firearm for specimen collection is a difficult proposition. Although its selection is mostly a matter of personal choice, it is through the years of field experience and personal knowledge that certain weapons could be identified as more suited for specific mammalian species. Moreover there is practical difficulty of carrying too many arms or ammunition in the field along with other gear. It is proper to limit the number of arms and to be specific about the object of collection. Shooting is not the end in itself, taking of measurements, skinning and preparation of skeletons are time consuming jobs. Care of arms and ammunition from dust, moisture or rain add burden to problems in field camps, so also the care and treatment of the specimens collected. Well selected weapons with matching ammunition will make field collecting more objective and fruitful.

It is important that the collector should be well versed and confident about the functioning of the ballistics vis-a-vis the specimen to be collected to avert catastrophe and to achieve the optimum advantage and utilisation of his armamentarium.

### SUMMARY

Firearm is an integral gear for the collection of mammalian specimens for the purpose of scientific study as well as for museum display. Due to the tremendous improvement in ballistics, there is a sea change in the development of arms and ammunition and today's weapons become obsolete tomorrow.

Nevertheless, the relationship or the selection of right arms along with the right ammunition to be used for a particular mammal is very important. The knowledge of rudimentaries like the muzzle velocity of a firearm, the composition of a cartridge or bullet, or the trajectory

they follow help a great deal in collection of a particular specimen with least of injury and less of pain. Moreover, skull and skeleton of the specimen collected, is also useful for scientific study. Their minimum damage has to be assured. The selection of arms or ammunition will, therefore, vary from a large mammal to a medium or a small one.

The paper deals with in detail the arms and ammunition that should be used in India for shooting and collection of mammals in their typical Indian habitat and the problems usually faced during their collection in the field.

#### ACKNOWLEDGEMENTS

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#### DISCUSSION

*Q. In North America, combination shotgun-rifles in an over-under style are widely used for collecting and hunting. Have you used such a weapon for collecting and do you find it useful ?*

A. Yes, I have used such combinations in different bores and found them very useful.

*Q. What arms and ammunition you would advise for the collection of mammals like Dolphin ?*

A. Neither I have collected any Dolphin nor do I know of any firearm suitable for collection of such aquatic mammal.



## **PERSONNEL POLICIES IN INDIA (ZSI) IN MANAGEMENT OF ZOOLOGICAL COLLECTIONS**

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### **INTRODUCTION**

The Zoological Survey of India is now 68 years old. It was founded in the year 1916 by the then British Government mainly because of the cumulative research findings of earlier naturalists like Edward Blyth, Alcock, John Anderson, and others. The Survey inherited the Zoological collections from the former Museum of the Asiatic Society of Bengal and of the Indian Museum at Calcutta. These collections have now developed through field explorations during the last six decades or so to the present holdings of more than a million specimens of all the animal groups from Protozoa to Mammal. The care, maintenance and preservation of the National Collections is one of the most important functions of the Survey.

The Zoological Survey of India is supported by many specialists working on almost all groups of animals. It is the only organisation which provides identification of zoological specimens of economic and general interest to various government departments, universities, research institutes, colleges, and even to interested individuals, without charging any fee.

The Survey has been exploring the rich and diverse faunal wealth of the entire country in almost all areas. It undertakes field surveys as a routine work for collecting of animals for studying their taxonomic status, bioecological features, biogeographical patterns, and the faunistic composition of a particular region or habitat in the country. When necessary, special surveys are organised to collect particular groups of animals. In recent years we have taken a mopping up programme to cover different states with an ultimate view to have the faunal picture of the entire country. As a result of these surveys and study a very large collection of determined specimens has been accumulated. Further specimens have been added through exchange and donation. More often individuals who send their material for mere identification, leave the material in the care of the ZSI as they are interested only in the classificatory aspect of their collections. By a special appeal made by me last year we are trying to obtain all the type material of the species described by various authors in the country in ZSI, now declared as the National Zoological Collections of India.



It is but natural that these collections and their management involve a lot of personnel. In view of the large size of the country and the widely diverse habitats, the collections so accumulated are rather huge. The work load consequently is also heavy and to meet with this situation we are often forced to place additional personnel for certain larger groups and are unable to adopt a uniform pattern of staffing at least in respect of numbers. To quote an example, it is well known that two-thirds of the animal kingdom is occupied by insects and it is but natural that Entomology occupies a prime place in ZSI in respect of the total number of staff.

#### ORGANISATIONAL PATTERN

The Zoological Survey of India as mentioned earlier, has to cater to all groups of the animal kingdom as far as possible. With this in view, we have divided the entire Survey into sections and divisions. The base unit is the section which is headed by a Zoologist in Group A level. The section comprises, in most cases, a Group B officer—Assistant Zoologist and a number of supporting staff such as Senior Zoological Assistant, Zoological Assistant, Junior Zoological Assistant, and so on. The typical composition pattern of a section is as follows :

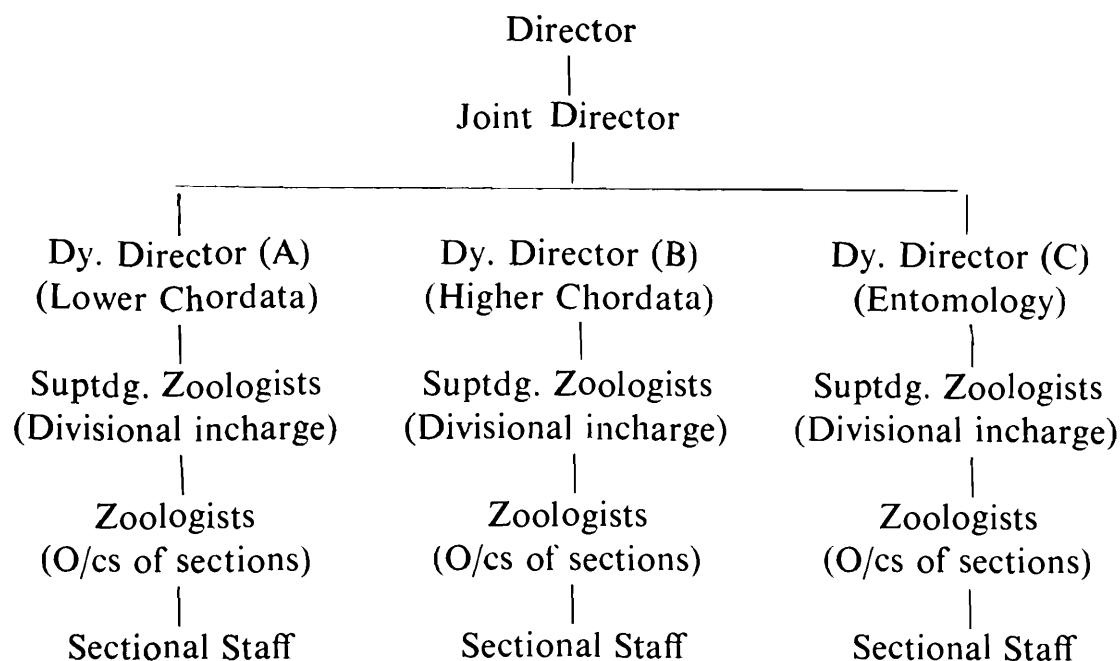
Zoologist—Group A, Incharge of the Section  
Assistant Zoologist—Group B  
Senior Zoological Assistant—Group C  
Zoological Assistant—Group C  
Junior Zoological Assistant—Group C  
Laboratory Assistant—Group C  
Collection Tender—Group D  
Lab. Attendant—Group D

Most sections have this pattern. The number of personnel posted against each category varies depending upon the size of holdings and the groups of animals allocated.

There may be a section without a Group A level scientist, if the work load is light or the holdings do not warrant such a position. Often we have clubbed together two or three groups of the animal kingdom under one section such as Amphibia and Protochordata.

Three or four sections are placed under a division with a senior scientist at the supervisory level. For example the Birds and Mammals are placed under one division though there are separate sections for these, each section being headed by a Zoologist. Several divisions are grouped and placed under a Deputy Director who in turn reports to

the Joint Director and the Director. The general organisational pattern in the Head-quarters is as under :



The main responsibility of research and maintenance of collections is with the Zoologist or the scientist who is incharge of the section. Invariably for this purpose, as far as possible, a specialist trained and with expertise in a particular group is posted in that particular section. Thus for the Mammal section the officer-in-charge is a mammalogist by training and specialisation. This is adopted in most cases, but often it may not be feasible to place a particular specialist in the section dealing with the group of his specialisation because of non-availability of the particular position in that section. Thus, for an example, I may cite the posting of a Coleoptera specialist in the Invertebrate Palaeozoology Division since there is no position available of his specialisation in the Coleoptera Section. However, though he is administratively held responsible for the section under his charge, he has the freedom and choice to continue work in his group of specialisation. We are trying to rectify these anomalies by restructuring the entire cadre in a flexible component manner whereby all these difficulties will be solved. The Zoologist-in-Charge of the section is also responsible for the care, maintenance, proper registration and up-keep of the collections. His duties are as follows :

- (i) Research in the group and attend to identification and enquiries
- (ii) Care and maintenance of collection
- (iii) Supervision of work of the section

The supporting staff generally assist the Zoologist-in-Charge in various duties. The Collection Tender, as the name indicates, is a trained person by years of long training and may often not be specially qualified academically or in the field of Zoology. He replenishes preservatives of the collections and looks after the proper upkeep of the collections. He

does not have the responsibility of attending to loans or exchanges or cataloguing work which are looked after by the senior supporting personnel. The research is generally carried out by Senior Zoological Assistants and the staff above this level.

#### PROBLEMS OF MANAGEMENT

The major problem in management of these collections is the non-uniform pattern of staffing. Thus certain sections may not be having adequate staff to cope with the rush and clearing of backlog of work, and at the same time there may be some sections where the staff posted may not have that much work to attend to. Reshuffling and posting of the personnel is beset with difficulties in a federal structure as ours, since we are obliged to show a definite person against the sanctioned post. Even at the proposal stage for more personnel we have to justify the requirements and categorically indicate where the strengthening would be needed. Moreover, a section such as that of Mammals, needs persons who are trained in the work and it may not be helpful if a man trained in pinning insects all through his career is posted there or vice-versa. Also, as the future prospects of the employee have to be kept in view, and with the promotions on seniority particularly at the lower level, certain anomalies are bound to occur. In a large country like India where manpower is cheap and with the avowed aim to provide job to the unemployed, no strict policy in the matter of recruitment or education can be laid down at the lower level. Perhaps this may be true in almost all the developing countries.

The maintenance of collections are mostly done manually by these trained persons. Unlike western countries, mechanical devices are neither used nor necessary. The depredations due to weather, and damages in handling, transit, routine examinations, periodical dusting, removal during pest control operations, etc., are kept in check with the help of these trained persons who know the value and importance of collections.

#### SUMMARY

Management of Zoological Collections is peculiar in a sense that these collections are beset with several problems. This is especially so in a developing tropical country like India where we are by necessity forced to keep a balance between men and material. In the Indian context the choice of this appropriate composition of the personnel structure involves, bringing a proper balance between the specialist and generalist with a limited use of mechanical devices. With a broad two tier system of the specialist and supporting staff, the primary aim is to diversify capability even among specialists to enable them to oversee and supervise collections of differing nature. These aspects are elaborated in this paper.

## **USE OF STAFF AND ADMINISTRATIVE HIERARCHIES : USA**

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### **INTRODUCTION**

Professional and technical personnel of a museum often perceive their administration as, at best, a necessary evil. In many instances, this perception is accurate. In some instances, in fact, the administration actually detracts from the satisfactory performance of personnel in carrying out museum programmes. This need not, and should not happen.

Administrative and staff hierarchies represent lines of authority and communication, and should be designed so to maximise staff efficiency. The purposes of this paper are : first, to characterise the kinds of administrative and staff hierarchies that exist for natural history museums in the United States, and to explain how these hierarchies affect the responsibilities of museum personnel; second, to define responsibilities and functions of the administration, curators, and staff of a museum; and finally, to propose ideas to consider in establishing new museums.

### **ADMINISTRATIVE HIERARCHIES IN AMERICAN MUSEUMS**

Administrative hierarchies for university museums often are the result of historical accidents. As such, they reflect how someone, at some time in the past, interpreted the role of the museum within the larger role of the university. More often than not, a new president of a university reorganises the administrative hierarchy, and this sometimes shifts the chain of command for a museum from one administrator to another. And, because museums often are not a principal concern of new university presidents, little thought may be given to alternative administrative hierarchies. As a result, the museum may be added to the bottom of some administrator's list of responsibilities, and no effort may be made to assess which of the possible lines of authority would be best for the museum. Fortunately, administrative hierarchies at most universities are changeable, and a strong museum director may be able to modify the hierarchy to suit the needs of the museum. Although university museums emphasise education (Williams, 1969) as their principal function, research and service also are important. The priority assigned to these functions depends on the administrator to whom the museum director reports.

The director of a university museum usually reports to a vice president, a dean, or the chairman of an academic department. Large museums typically are the responsibility of a vice president. The Vice President for Academic Affairs (Fig. 1*a*) is the chief officer for all academic functions at most universities; he is charged with quality and quantity of education at the university, and also may oversee the research and service functions. He reports directly to the President and, of the potentially many vice presidents, he characteristically is the most powerful. Accordingly, museum directors who report to the Academic Vice President need convince only one person—or two if the President becomes involved—to obtain approval for museum programmes. On the other hand, if the answer is “no”, there is nowhere else to go—there is no other administrator to argue the cause of the museum for you. And, because the Academic Vice President is in charge of all educational functions, he may slight programmes, such as those of museums, that emphasise research or public service and are involved indirectly in education but may not generate credit hours. In short, the Academic Vice President is not an appropriate administrator for a university museum unless: (1) the emphasis of the museum is education; (2) the vice president understands museums; (3) the vice president is in charge of, or fully appreciates, research.

A second vice president to whom some university museum directors report is the Vice President for Support Services (Fig. 1*b*). This administrator commonly is responsible for the provision of services to the campus community. These services may include libraries and museums as well as maintenance of buildings and grounds. The service-oriented philosophy of the Vice President for Support Services is totally inappropriate for the administrator of a museum, in which service to the campus community typically is a relatively minor function (but see Guthe, 1966).

Another vice president to whom some directors of university museums report is the Vice President for Research and/or Graduate Studies (Fig. 1*c*). This vice president often has been involved in research himself, and typically understands many of the problems museums have in carrying out their programmes. Moreover, because this vice president is responsible for research and/or graduate programmes, he is less concerned than the Academic Vice President with quantity than with quality of programmes. Finally, this vice president may control the research funds of the university, some of which may be available to help support museum programmes. On the negative side, this vice president typically has less power than the Academic Vice President and must be an effective negotiator if his programmes are to receive the attention they deserve. Also, because many of the programmes that report to the Vice President for Research and/or Graduate Studies may be funded through grants and contracts, the

# Common Alternative Administrative Hierarchies for University Museums (USA)

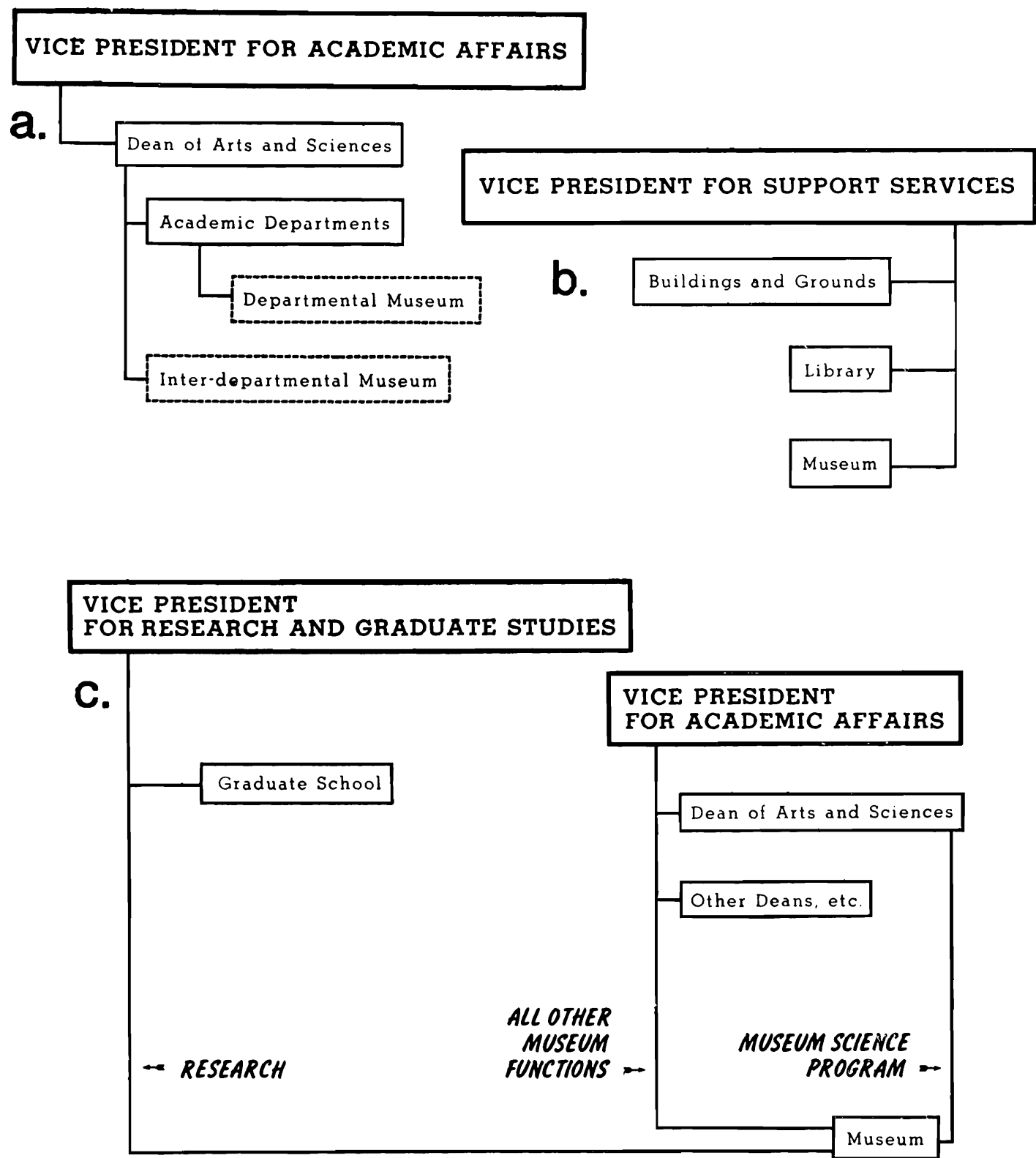


Fig. 1. Common alternative administrative hierarchies for university museums.

vice president must be an effective fundraiser. In short, the Vice President for Research and/or Graduate Studies is an appropriate administrator for a university museum if: (1) the emphasis of the museum is research; (2) the museum interacts with academic departments in the training of graduate students; and (3) the vice president is an effective administrator who can influence other administrators.

A fourth vice president to whom some directors of university museums report is the administrator responsible for, among other things, public relations. This person may have any of a number of titles; at my university he is the Vice President for University Development and Relations. I will illustrate this administrative hierarchy later. The Vice President for University Development and Relations is charged with promoting good relations with the public and alumni and with soliciting endowment funds for the university. Accordingly, his departments often include programmes that appeal to the public—athletics, museums, and so on. Some of these programmes, especially athletics if the teams have winning records, generate money for the university, and the Vice President for University Development and Relations may be able to procure some of that money for his programmes. Accordingly, this administrative connection can be of benefit to museums. Also, because this particular vice president has no connection with academic programmes, he tends to be interested in quality of programmes rather than quantity. Actually, his greatest interest is in appearances; if his programmes look good, they attract endowment funds. Therefore, this vice president is enthusiastic about museum exhibits, special programmes for the public, practical research, and anything else he can wave in the face of potential benefactors. On the negative side, the Vice President for University Development and Relations typically has less power than administrators concerned with academics, but this is countered by the fact that he may have the president's ear as a result of his involvement in fundraising. In short, the Vice President for University Development and Relations is an appropriate administrator for a university museum if: (1) the museum has exhibits and emphasises programmes designed to benefit the public; (2) at least some of the research conducted in the museum has public appeal; and (3) the vice president is effective in fundraising and in other interactions with the public.

Directors of small, interdisciplinary university museums sometimes report to the Dean of Arts and Sciences (Fig. 1a), who in turn reports to the Academic Vice President. This can be a disaster; the Dean has all the concerns related to quantity of programmes that I mentioned earlier for the Academic Vice President, but much less power. Accordingly, he may have little time or concern for "unimportant" programmes such as museums, which neither generate credit hours nor contribute directly to the academic programmes in his charge. Even if museums sponsor academic

programmes, they are not apt to have large enrollments and therefore may be relatively insignificant in the eyes of the dean. Or, even worse, the academic programmes may be for graduate students and therefore may not fall within the realm of influence of the dean. In short, the Dean of Arts and Sciences is a suitable administrator for a university museum only if: (1) the dean really understands and appreciates museums and research, (2) the dean is influential with the Academic Vice President; and (3) the museum functions primarily in support of academic programmes.

Directors of small, departmental university museums typically report to the chairman of an academic department, such as the Department of Biology (Fig. 1a). The chairman may regard the museum as an important part of the department, in which case he will be supportive. Or, he may regard the museum as a liability that costs too much and takes too much space. If the chairman thinks of the museum as a liability, the only hope for the person in charge of the museum is to convince a higher administrator of the need to remove the museum from departmental control. If the chairman supports the museum, he can be an effective administrator even though he is at the bottom of the administrative pyramid. In a museum where the objective is to remain isolated from the public and conduct relatively inexpensive research, there can be no better administrator than a benevolent departmental chairman. If, however, the museum needs extramural funding for large projects or has exhibits and conducts programmes designed to benefit the public, the departmental chairman has too little power to be an effective administrator. Moreover, the departmental museum is never conceived as any more than a resource for the benefit of departmental programmes. In short, the chairman of an academic department is more suitable as an administrator for a small museum than is the Dean of Arts and Sciences but, as the museum grows and its programmes expand, it may become necessary to transfer the museum to the hierarchy of a higher administrator.

Actual administrative hierarchies for university museums are illustrated by two examples, the first a small university with two museums and the second a large university with one museum complex.

Fort Hays State University (Fig. 2) is a small, state-funded university with fewer than 6000 students. It offers programmes of study leading to undergraduate and graduate degrees but does not confer the Ph.D. degree. It has two museums, the Sternberg Memorial Museum and the Museum of the High Plains. The Sternberg Memorial Museum has exhibit halls and provides programmes of public service and education. It houses more than 2,000,000 specimens, including an outstanding collection of fossils, but has no collections of Recent plants or animals. The Museum of the High Plains has no exhibits and is used primarily in research and graduate education. It houses about 750,000 specimens, including the world's



## ORGANIZATION CHART—FORT HAYS STATE UNIVERSITY

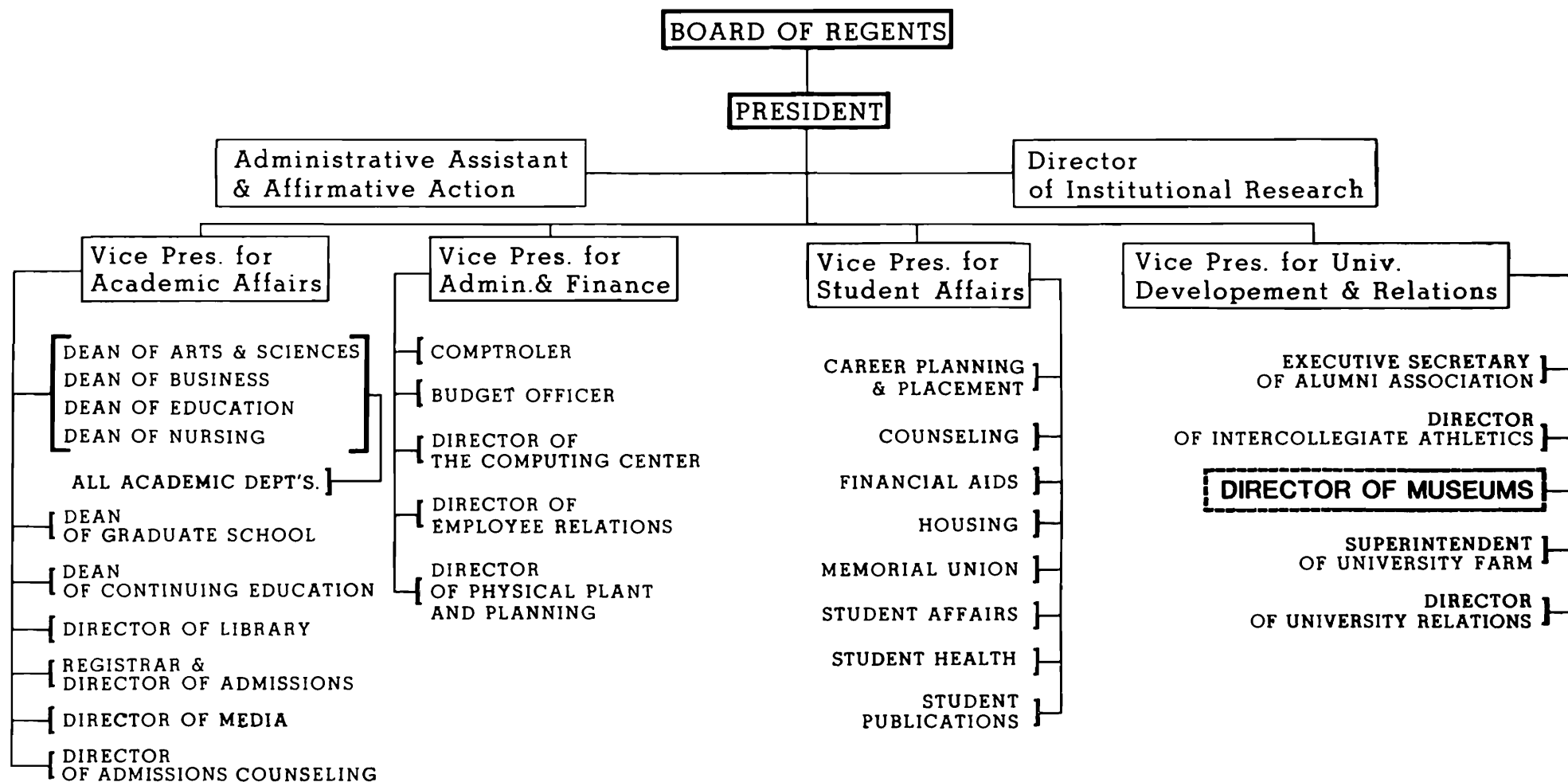


Fig. 2. —Administrative hierarchy of Fort Hays State University, showing position of Fort Hays Museums with respect to other programmes of the university.

largest collection of fossil grasses and nearly 25,000 mammals, in separate collections of Recent mammals, birds, reptiles, fishes, insects, and both Recent and Fossil plants.

The two museums each has an assistant director who supervises staff activities and administers routine operations of his respective museum. The assistant directors report to a common director, who is responsible for managing the budgets and coordinating the programmes of the museums. The director also administers the joint educational and public service programmes of the two museums and oversees the activities of an association of local citizens who participate in museum functions.

The director reports to the Vice President for University Development and Relations. This vice president is one of four who report to the President of the university, who, in turn, reports to the State Board of Regents. The Board of Regents is appointed by the Governor of Kansas and receives its authority from the State Legislature; it serves as the top administrator for the university and its museums. This administrative hierarchy is simple and orderly, and has no multiple lines of authority.

Texas Tech University (Fig. 1c), on the other hand, is a large, state-funded university with about 24,000 students. It confers undergraduate and graduate degrees, including the Ph.D. It has one university museum complex that includes the museum proper, a cultural center, and a historic landmark. All three units of the museum complex have exhibits or otherwise appeal to the public. The museum proper houses collections representing numerous disciplines, including more than 40,000 Recent mammals.

One director administers all the programmes of the Texas Tech University museum complex. The chain of command becomes complicated above the level of director because different programmes of the museum are the responsibility of different administrators. The museum's academic programme, which leads to an M.A. degree in Museum Science, falls under the Dean of Arts and Sciences, who subsequently reports to the Vice President for Academic Affairs. However, because this academic programme is for graduate students, the director also reports to the Dean of the Graduate School, who reports to (and happens to be the same person as) the Vice President for Research and Graduate Studies. The director also reports to this vice president with respect to research undertaken in the museum. The Vice President for Research and Graduate Studies is the top administrator so far as research is concerned, but he, in turn, reports to the Vice President for Academic Affairs regarding academic programmes at the graduate level. Finally, the director also has a direct line

to the Academic Vice President, who in this capacity generally oversees all programmes of the museum. Accordingly, the Academic Vice President is the director's most powerful administrator but the director has the advantage (or disadvantage, depending on the circumstance) of having two additional administrators with whom to negotiate programmes and from whom funding potentially can be obtained. This bureaucratic administrative hierarchy is much more complex than those in smaller universities, and in fact it is much more complex than I have explained it to be here. Depending on the personalities involved, this complexity can be a liability or a benefit. The one thing such bureaucracy is certain to do is increase the volume of paperwork required of the director

Administrative hierarchies in large public or private museums in the United States reflect two external sources of influence. The first is the world of business. A large public or private museum is, in fact, a business with an appreciable operating budget and a staff that may number in the hundreds. The product that the museum sells is service, both to the general public and to society at large. Income from sales of service comes only in part from the immediate beneficiaries of the service, and then only if the museum charges an admission fee. Rather, most funds are received from corporations and wealthy individuals who recognise their obligation to support the needs of society or, more often, need a tax write-off. Another source of funding is foundations, many of which are philanthropic organisations established to minimise tax indebtedness. Accordingly, the higher administration of a large public or private museum often is concerned mostly with fundraising, and the administrative hierarchy of the museum typically is organised in businesslike manner to insure the effective use of funds and the maximal generation of services.

The second external source of influence on the administrative hierarchies of large public or private museums in the United States is academic. The curators and administrators of such museums often are frustrated academicians; the developmental stages of their professional careers were spent at universities, and they never lost the itch to return to the serene, thought-provoking atmosphere in which they spent their most impressionable years. One result is a tendency to rely heavily on the university committee system of management, which functions as a small trade union, for example of curators, to compile and convey concerns from the working level of the museum to the administration or to implement programmes originated by the administration and passed down to the working level of the museum (Nicholson, 1974). Another result is that salary scales and professional promotions often are based on those at universities and, if the comparison with a trade union holds true, there may be little or nothing in the way of merit increases in salary for high productivity or meritorious performance (Parr 1958). In these ways, the administrative

hierarchy may be designed in conservative, businesslike manner to maximise efficiency yet may exhibit symptoms of bureaucracy that tend to stifle productivity.

The mission of a large public or private museum stems from its commitment to serve the public and society at large. Accordingly, such museums emphasise public service (including public education, but not education as practiced at universities) and research. To maximise the quality and quantity of public service and research, these functions are at least partly separated from each other by the administrative hierarchy (Parr, 1958). In other words, exhibits and public education programmes tend to be isolated from scientific collections on separate lines of authority. In this manner, scientists associated with museums are used as a resource in planning and designing programmes for the public but are insulated from routine public inquiries and daily public service activities. This enables curators and other scientists to spend the majority of their time doing what they are most inclined to do—that is, research and curation (Parr, 1958)—and relegates the routine tasks of providing services to museum educators and technicians hired specifically for that purpose. That is not to say that curators are entirely isolated from the public; they still respond to inquiries relating specifically to the collections in their charge. However, the degree of insulation provided by the administrative hierarchy minimises routine intrusions that can be handled just as well by someone with less, or different, professional or technical training. This, to my way of thinking, is the greatest advantage of the more businesslike administrative hierarchy of private or public museums over those generally found in academic museums.

The director of a large public or private museum may be at the top administrative level of the museum hierarchy. Or, he may report to a higher administrator who is responsible for several museums or comparable institutions. Or, he may report to a governing board of laypeople who possess final authority in matters related to the purse-strings of the museum. Finally, he may report to a public official or governmental agency whose role resembles that of a governing board of laypeople. The design of the administrative hierarchy is dictated by the nature of the museum and the source of funding for the institution. More times than not, the hierarchy is fixed. The administrative hierarchy cannot be changed as readily as it can in a university setting. Accordingly, the director selected for such a museum must be a persuasive negotiator who can deal effectively with his higher administration. Moreover, he must be able to convey the mission of the museum, the excitement of reaching out for goals within that mission, and the certain public benefits of activities associated with those goals to a sometimes disinterested or overly budget-minded group of individuals or bureaucrats. This is nearly the reverse of the situation found in

university museums, where the appropriate higher administrator conceivably can be selected to deal with the museum director.

Perhaps the difficulty of the role of director of a public or private museum explains why many directors are ineffective, at least in the eyes of their subordinate staff members. This also might explain why persons other than scientists who have worked their way up through the ranks of the museum often are selected as directors of such museums. There are two ways of looking at this matter. A former curator who has worked his way up to the level of director of a public or private museum understands the museum better than any non-scientist ever can, but the former curator has spent most of his life intentionally insulated from the public and often has not become an accomplished practitioner of public relations. A businessman or an extroverted entrepreneur, on the other hand, would be much better suited for dealing with the public and with higher levels of authority, but doubtfully ever would fully understand the inner workings of the museum and never could hope to develop the "museum conscience" that characterises his curators—without which he cannot understand his curators (Parr, 1973). I do not propose to say which option is best; in selecting a director, the only guidance I can give is to pick the person who seems least likely to do the worst job.

The administrative hierarchy of the Carnegie Museum of Natural History illustrates the businesslike chain of command in large public or private museums. The Curator of Mammals (Fig. 3) is one of six curators who report to the Chief Curator of the Life Sciences Division. The chief curator, in turn, reports to the director of the museum. The Chief Curator of the Life Sciences Division (Fig. 4) is one of three chief curators for systematic collections, and all three are separated from the other major areas of responsibility in the museum, such as exhibits and education, by the administrative hierarchy. This formalises the isolation I mentioned earlier, which protects the curators of collections from excessive involvement in activities other than curation and research. The Director of the Carnegie Museum of Natural History (Fig. 5) is one of four directors and several other administrators who report to the President of the Carnegie Library and Institute. The president is the top administrator, but his decisions undoubtedly are influenced by pressure from individuals, foundations, corporations, and other organisations whose contributions constitute much of the operating budgets of the library and the museums.

#### STAFF HIERARCHIES AT REPRESENTATIVE MUSEUMS

Staff hierarchies in American museums ideally protect the curators from interruptions and routine technical work that can be handled as

# CARNEGIE MUSEUM OF NATURAL HISTORY

## LIFE SCIENCE DIVISION

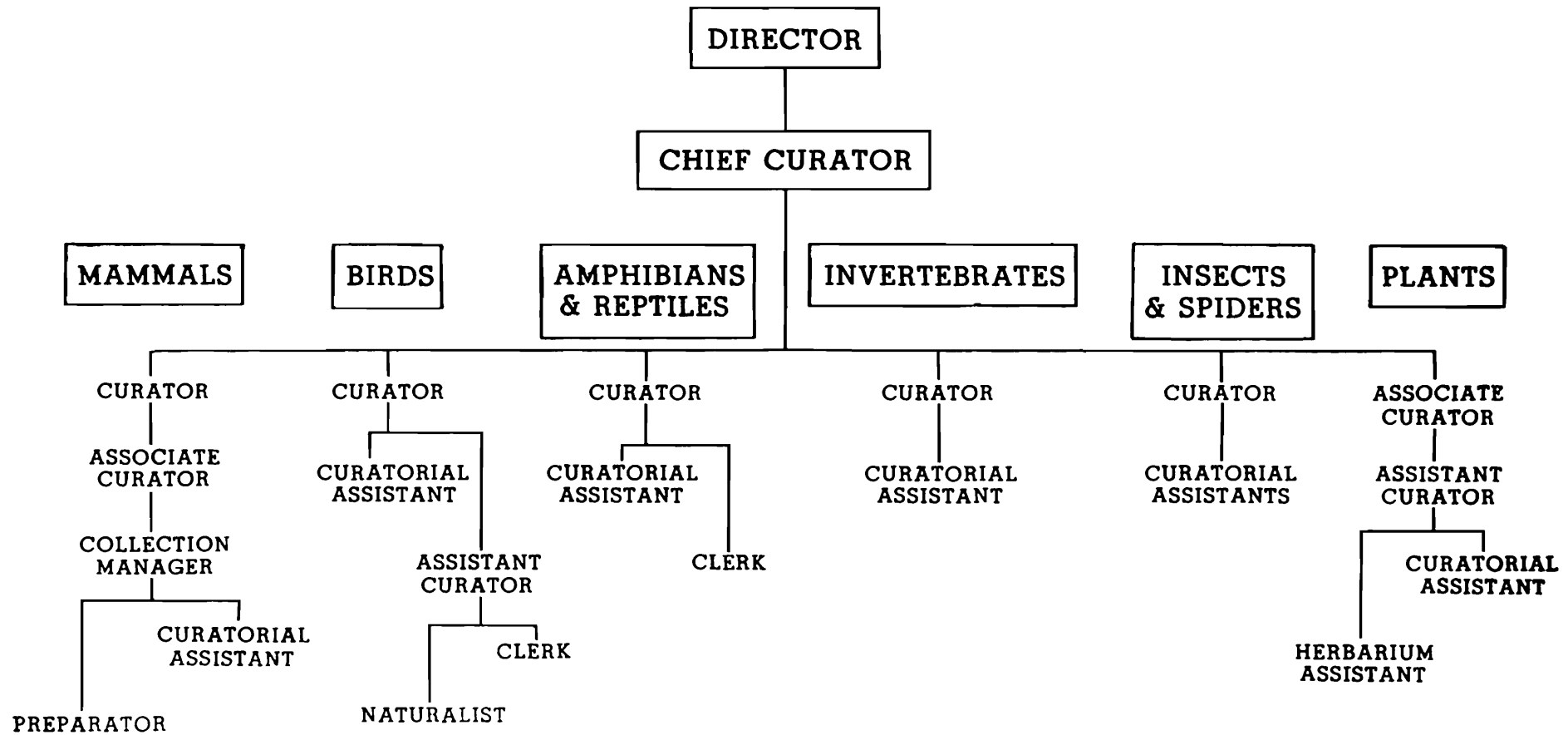


Fig. 3.—Administrative hierarchy of the Life Science Division of Carnegie Museum of Natural History.

# CARNEGIE MUSEUM OF NATURAL HISTORY

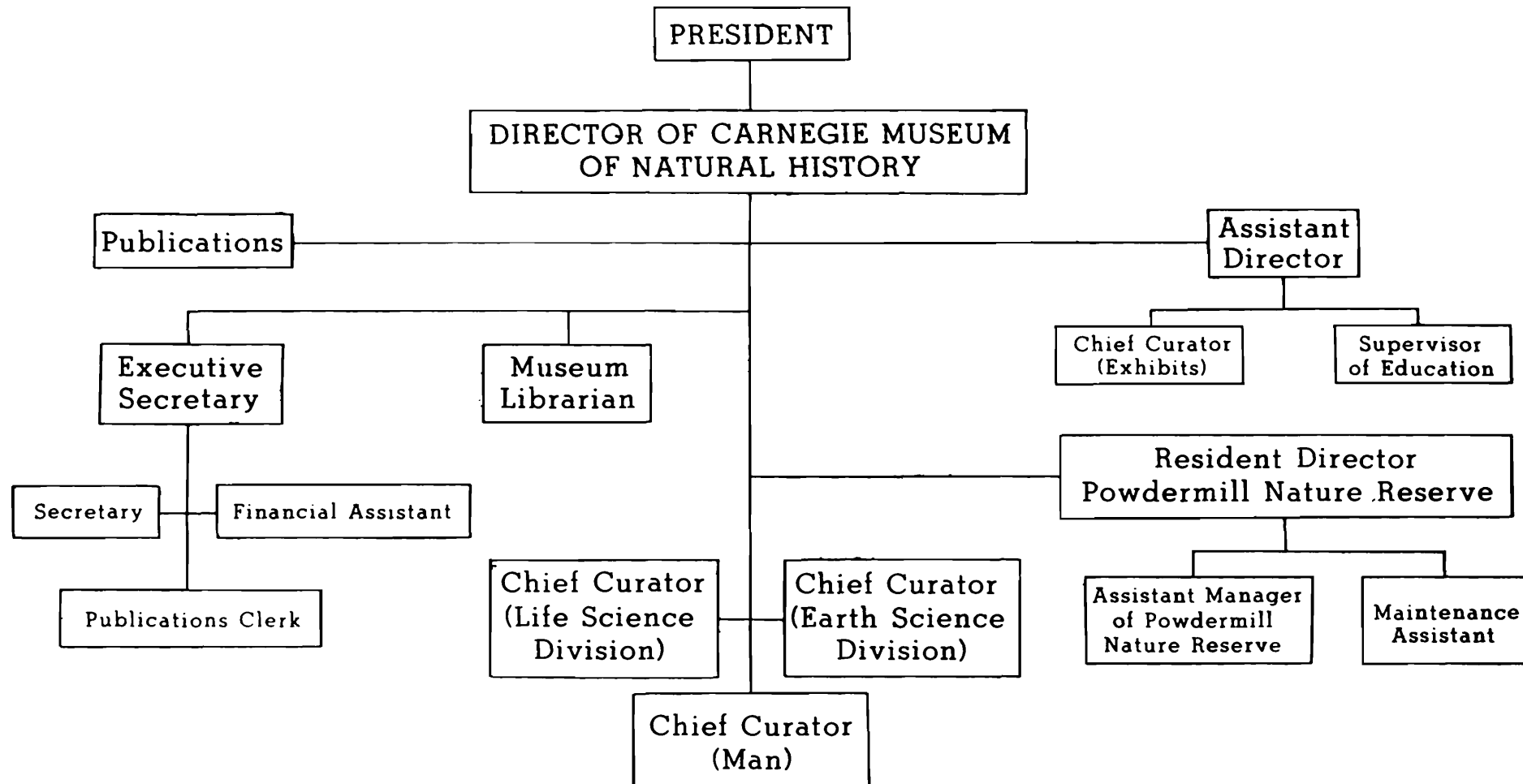


Fig. 4.—Administrative hierarchy of Carnegie Museum of Natural History, showing position of the Life Science Division with respect to other divisions and offices of the museum.

# CARNEGIE INSTITUTE AND LIBRARY

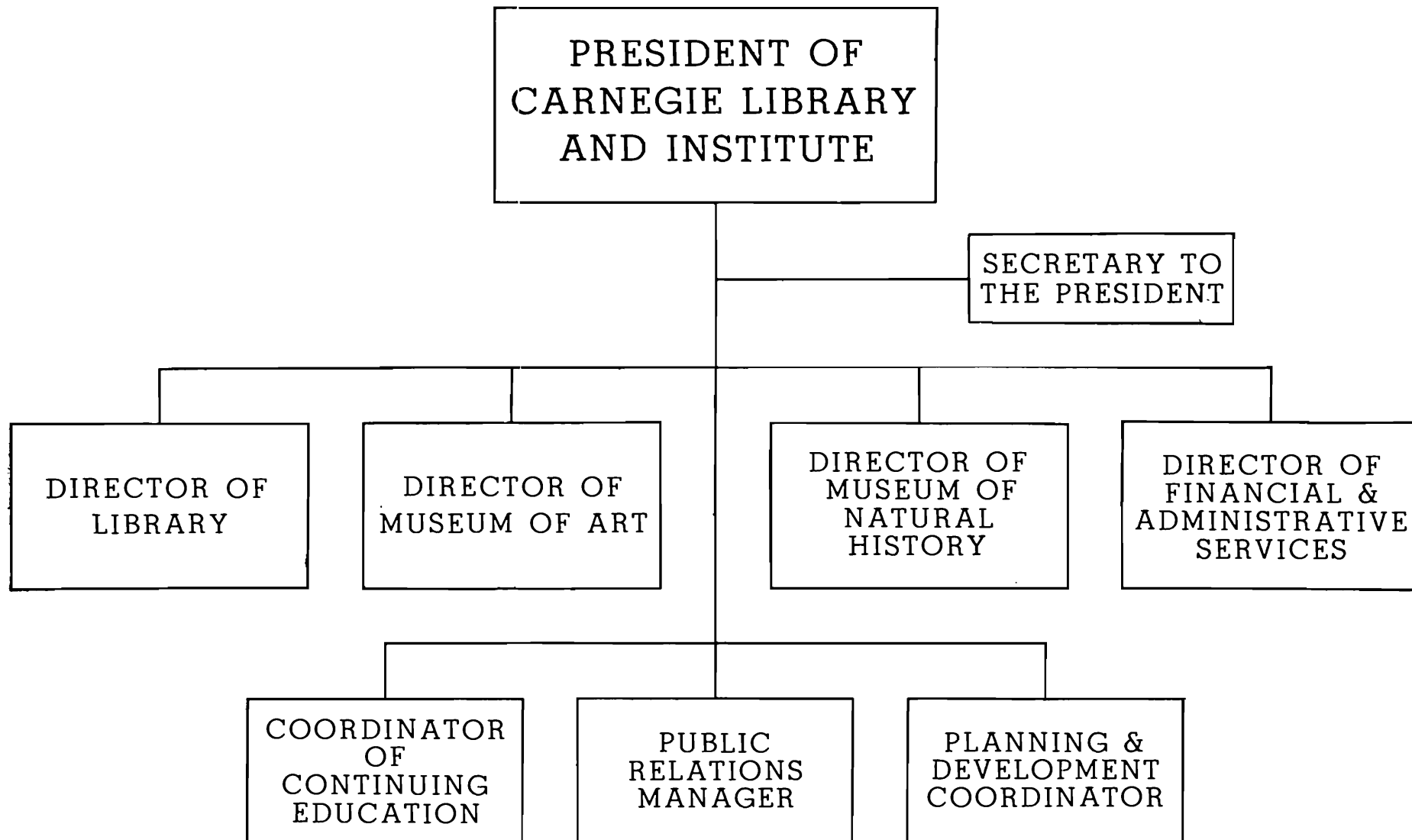


Fig. 5.—Administrative hierarchy of Carnegie Institute and Library, showing position of Carnegie Museum of Natural History with respect to other museums and functions of the organisation.



well or better by technicians than by a scientist. Such protection is not possible at very small museums, where the curator, in addition to curating the collection in his charge, may function as an educator, a carpenter, a preparator, and a clerk/typist during the day, and then sweep the floors before leaving the museum in the evening. However, at most museums the curator is afforded relief from at least some of these routine activities in the form of staff assistants. This is true for both university museums and private or public museums, but the ways in which these different kinds of museums protect their curators usually differ appreciably. Again, I must generalise somewhat and illustrate "typical" museums in order to point out these differences.

The staff hierarchy for the museums at Fort Hays State University (Fig. 6) illustrates how labour-intensive university museums may be. The most active collections in the two museums have the greatest number of student assistants, but the curators of even relatively inactive collections at least have student secretaries. The reason for this heavy reliance on student labour is that the curators have numerous responsibilities other than curation.

Few university museums have full-time curators. At American universities, curators are expected to teach classes, work with graduate students, conduct research and publish the results in scholarly journals, seek and obtain extramural funding, participate in the deliberations of innumerable committees, advise the administration, be respected members of the community, respond to requests from governmental agencies, participate in various professional activities, and, if any time remains, curate the collections entrusted to them. Of these duties, teaching and out-of-class activities with students that result from teaching take the most time and effectively break up the day so that few uninterrupted blocks of time remain for curation. Accordingly, curators in university museums cannot really curate their collections (Colbert, 1958); all they can do is teach someone else to curate the collections for them—of course, under their watchful eye. Fortunately, eager students are plentiful. These students, whether paid for their help, awarded college credits, or simply "permitted" to work without remuneration just for the experience, comprise the mainstay of the actual labour force in university museums.

A curator typically picks a graduate student or an advanced undergraduate as curatorial assistant. This person actually assumes much of the role of curator for the collection so long as he retains that position. The curator carefully trains the curatorial assistant and works with him until he is confident the student thinks like the curator. This is important; for the curatorial assistant to be effective in the eyes of the curator, the curatorial assistant must make the same decisions under all

STAFF HIERARCHY  
OF FORT HAYS STATE MUSEUMS [USA]

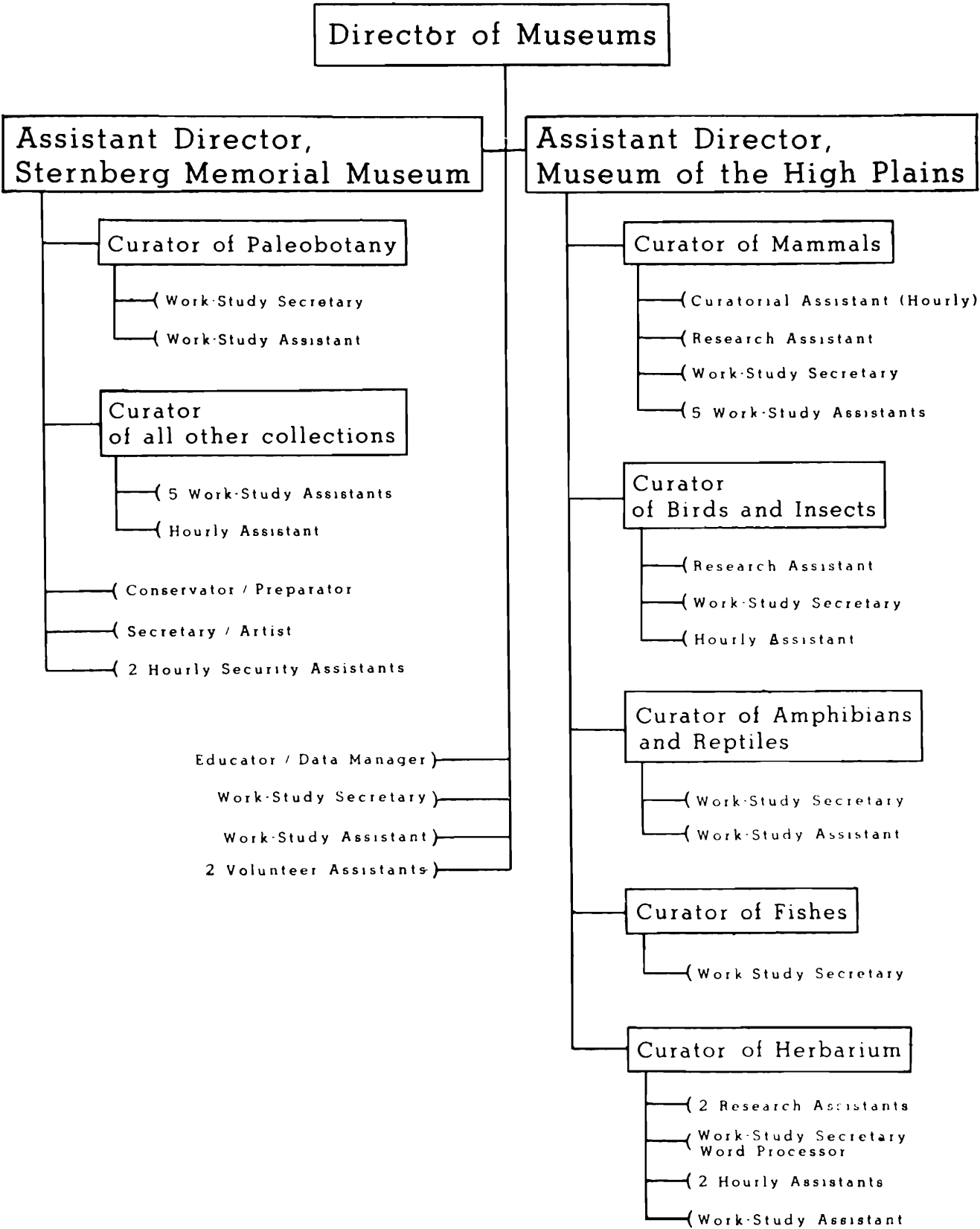


Fig. 6.—Staff hierarchy of Fort Hays State Museums.

circumstances as the curator would make. One way the curator can insure that subsequent curatorial assistants always respond the same in a given circumstance is to prepare a curatorial manual in which the technical labour of curation is carefully explained. Of course, some decisions must remain the responsibility of the curator, but a well-trained curatorial assistant, perhaps working half-time while taking classes at the university, can protect the curator from most of the repetitive functions of curation.

Like curators, curatorial assistants also become overworked. This is especially so when skeletal materials must be cleaned and numbered or computer files must be updated or corrected. Accordingly, at most university museums the curator recruits other students to assist the curatorial assistant. In the United States, the so-called "work-study programme" provides a minimal salary to needy students to work while attending college. This programme enables museums to hire students at little cost to the museum to help in curatorial activities. The curator or curatorial assistant can train work-study students to clean and number skeletal materials or manage a computer file, after which time the curatorial assistant can assume responsibility for supervising their work—again, under the watchful eye of the curator.

A student secretary is almost as valuable to a curator as his curatorial assistant. Student secretaries may be employed inexpensively with work-study funds, and typically may work 10 to 20 hours per week. Some are accomplished typists, perhaps training as business or legal secretaries or office managers, and even can perform such functions as word processing after they become familiar with the particular computing system available to the museum.

Students also function in other ways in university museums. I have one assistant who helps curate but also doubles as an artist, and two husky football players who serve as guards for exhibits. Finally, graduate students who use a collection in their thesis research are expected to participate in the curation and maintenance of the collection as part of their professional training.

Staff hierarchies in large private or public museums serve the same purpose as those in university museums, but they are designed differently. For one thing, there commonly is more than one curator for a collection, and the curators may partition responsibility for the collection either taxonomically or geographically. This is illustrated by the staff hierarchy for the Section of Mammals at the Carnegie Museum of Natural History (Fig. 7). Second, the curators and many other paid staff members have full-time positions. The most important of those staff positions typically is the collection manager, who may have a masters

degree in museum science and be a highly trained museum technician. The nature of other positions depends on the emphasis of the collection, but there usually are more full-time positions and fewer part-time positions, at least relatively speaking, in large public or private museums than in university museums. Moreover, the full-time appointees have fewer responsibilities that take them away from the collection in public or private museums than in university museums. Part-time positions at public or private museums may include work-study students from nearby universities and almost always include volunteers, who generously donate their time and may become excellent museum technicians.

#### USE OF STAFF

In the United States there is a saying: "When you are young if you are not a liberal you have no heart; when you are older if you do not become conservative you have no smart" If one believes this proverb, then the time in one's professional career to consider stepping up to the position of museum director coincides with the time one begins to vote Republican! This generalisation may not be valid, but the fact remains that a director must focus as much attention on the well-being of the organisation as a whole as on the well-being of the individuals that comprise the organisation. Accordingly, the person selected as director should have vision, and should be able to lead, not push, his curators toward envisioned goals.

The first responsibility of the director is to perceive the mission of the museum. I say perceive, because museums have missions even if they never have been enunciated as such. By a mission, I mean a statement of purpose: the mission of the Fort Hays State Museums is to preserve the past, explore the present, and thereby assist society in planning for the future of the Great Plains region of North America. This mission does not restrict investigations in areas other than the Great Plains or even outside North America so long as those investigations can be related to the Great Plains region. A director who perceives the mission of a museum can better represent the museum professionally, to the public, and to higher administrators.

With the mission of a museum in mind, the director can define short-term and long-term goals of the museum, hopefully with input from the curators, and can allocate resources so to develop, maintain, or enhance programmes identified by those goals. In this regard, the director should evaluate planned activities to ascertain that they relate to the goals, and should coordinate all goal-directed undertakings. The director must do everything possible to insure that funding is adequate to

# STAFF HIERARCHY FOR SECTION OF MAMMALS, CARNEGIE MUSEUM OF NATURAL HISTORY [USA].

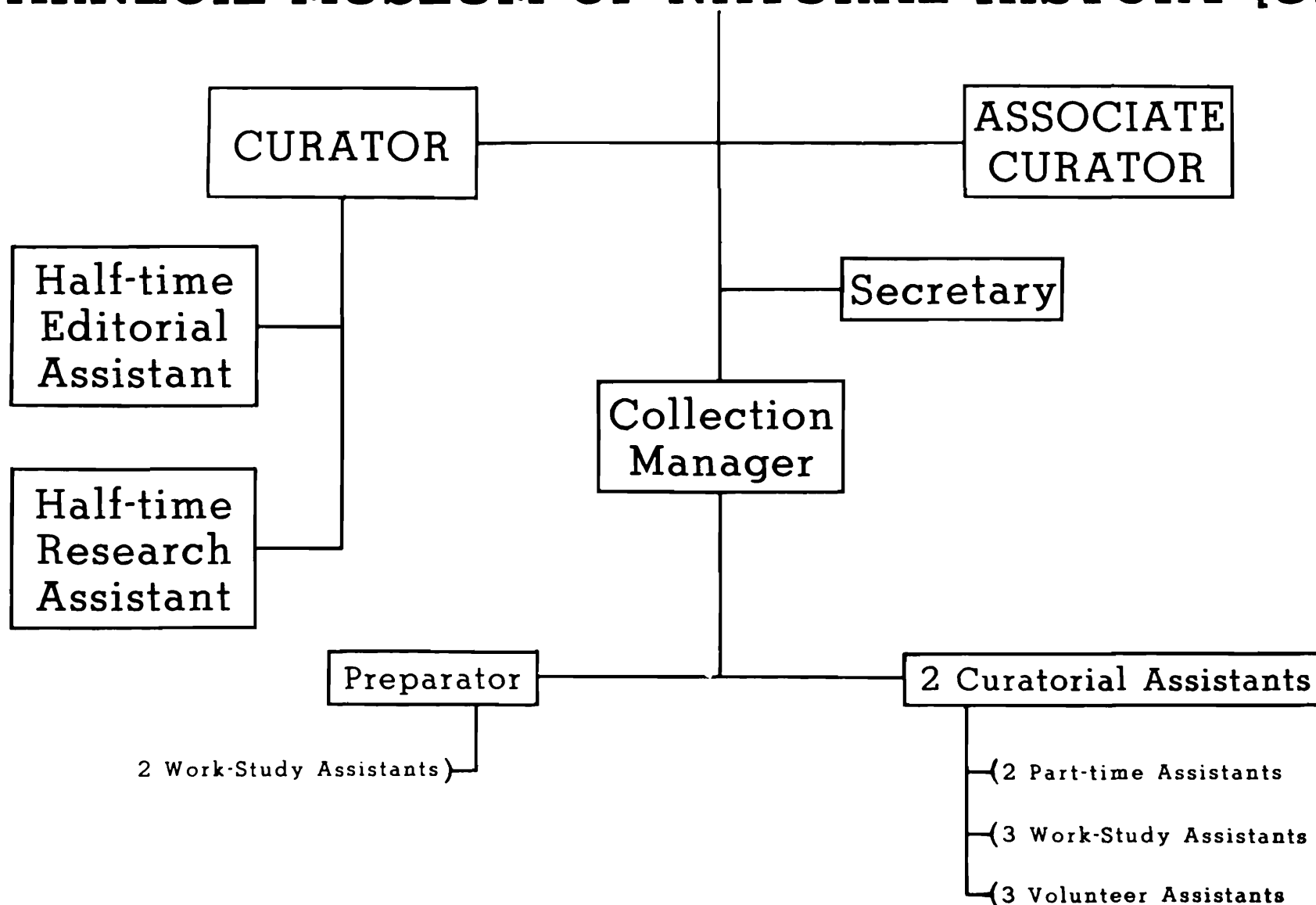


Fig. 7.—Staff hierarchy of the Section of Mammals of the Carnegie Museum of Natural History.

achieve goals, and is responsible for administering the museum budget (Apostolou, 1981; Clark, 1982). Some of that budget must be used to maximise the quality of facilities and working conditions. Once activities are underway, the director should evaluate their effectiveness. With respect to staff, the director is responsible for personnel management and can enhance productivity of staff by allocating wages based on merit. In dealing with personnel, the director should promote a smooth flow of communications in both directions. Also, the director must convey the flavour of the museum to the community, and should solicit input from the community regarding societal wants and needs (Hume, 1969).

The last, and perhaps the most important and least recognised, responsibility of the director is to realise just how unimportant he is to the museum. The actual work of the museum is accomplished by personnel associated with collections and other programmes. The activities of the director, at least ideally, are supportive in nature and should enhance the productivity of those persons, especially the curators.

The collections are the focus of any museum, and the curators of collections therefore are the most important persons in museums. Curators are the source of prestige, scholarly recognition, and creativity in museums. If a museum has a national or international reputation, it practically is never because of the activities of the director or those of exhibit personnel; rather, it is because of the activities of one or more of the curators.

First and foremost, curators are responsible for the collections entrusted to them (Grinnell, 1922). If a curator fails at everything else but is successful with respect to the collection in his charge, he will be remembered as an effective (albeit rather unproductive) curator. Most curators are expected to conduct research (especially on the collections of the museum), and this usually involves planning and supervising field expeditions designed to contribute to the growth of the collections and the enhancement of the research base (Parr 1958). Also, many curators participate in teaching or other academic functions at universities. With respect to exhibits, curators provide technically accurate information and can be a source of innovative ideas. Additionally, most curators administer a curatorial budget and supervise subordinate staff. The priority assigned to these roles differs in different museums, but research usually is emphasised (Colbert, 1958; Parr, 1958; Nicholson, 1974; Conway, 1978).

Finally, curators are the museum's link with nature (Amadon, 1971). As university faculties become more and more specialised and experimental, curators are among the few remaining "natural historians" It is especially important that curators perpetuate knowledge in the

broad field of natural history lest the field become stagnant or be lost altogether (Amandon, 1971). It also is important that at least some curators take a portion of their time to write popular articles and books that express the excitement of natural history to laymen and public officials (Bogert, 1958).

The most important function of the technical staff of a museum is to facilitate productivity in curation, research, education, and public service by the effective application of technical expertise. For the technical staff associated with a particular collection, this translates into doing everything possible to enhance the productivity of the curator (Colbert, 1958). For the exhibit staff or education staff, this means applying input from the curators (when needed) to the provision of services in these vital roles of the museum (Bergmann, 1974). Technicians must be highly qualified specialists within their fields, and these qualifications sometimes lead technicians to think of themselves as the focus of the museums. In this regard, technicians should remember that a museum can continue to function, albeit inefficiently, without a qualified technical staff. On the other hand, without professional curators, a museum ceases to be more than a warehouse with exhibits. Accordingly, the technical staff of a museum should rely on the curators for suggestions based on scientific knowledge, but should consciously avoid the temptation to take more from the curators than they give. On the other hand, curators should treat technicians as professionals and should recognise the invaluable expertise they possess—expertise others in the museum might not have—which can be used in the provision of services others in the museum might not have time to provide.

The support staff of a museum generally includes the secretaries (unless they are included among the technicians) plus assistants of various kinds who are paid by the hour or have part-time appointments, students hired with work-study funds or receiving college credit, and volunteers. The duties of these persons obviously vary from one museum to another. However, when their duties involve collections they should receive written instructions in the form of curatorial manuals (Choate *et al.*, 1977, 1978). The support staff of a museum can be almost indispensable to the effective provision of services of various kinds because these individuals can perform many of the functions that technicians and curators otherwise would have to perform. Therefore, it is critical that support personnel be selected carefully (Reibel, 1974), be trained meticulously in intellectually rewarding tasks (Flint, 1959; Compton, 1965; Heine, 1965; Seidelman, 1965), and be informed of the goal of the museum and the philosophies and methods employed to achieve those goals (Flint, 1959). Members of the support staff who are treated as professionals will work in a professional manner and will be deserving of professional and public recognition for their contributions (Flint, 1959).

## ESTABLISHING A NEW MUSEUM

As noted by Inverarity (1959), "The development of a museum is somewhat like the growth of a painting. The first stroke of the brush by its form, value, and color has a bearing on the last stroke of the finished painting." This demonstrates the importance of establishing the mission of the museum early on. If the museum is to be part of a larger institution, the mission obviously must be compatible with the objectives of that institution. Once the mission is established, it should be determined (Parr, 1962) whether the museum is to be a cooperative of separate departments, each devoted solely to its special interests (such as mammalogy or ornithology), or an integrated unit in which all departments apply knowledge from their disciplines to a central theme (such as man and his environments). Many large museums, such as the Carnegie Museum of Natural History, try to do both, but smaller museums and especially new museums should select one or the other strategy because the most appropriate administrative and staff hierarchies for the two types of organisations may differ. Most new museums begin as several independent collections, and automatically become a cooperative of uncoordinated entities unless a decision regarding the nature of the organisation is made at the beginning.

Next, the most appropriate administrator to whom the director will report should be selected. This administrator should participate in the selection of a director compatible with both the administrator and the persons who were involved in the initial organisation of the museum. One of those original organisers may be selected as director because he is more familiar than outsiders with the mission and type of organisation of the museum. Initially, the new director also may wish to serve as a curator, at least until the pressures of the two positions become too great for one person. Subsequent selection of other curators and staff (Schmidt, 1958) necessarily involves the appointment of persons qualified to function optimally within the limitations imposed by the mission of the museum and its type of organisation.

After the initial growth stage of a new museum, it may become necessary to revise decisions made regarding the mission and the organisation of the museum. In fact, if one of the goals of the museum is the provision of service to the public, then the wants and needs of the public will dictate periodic re-evaluation of museum programmes. Accordingly, museum personnel must be willing to accept changes in their responsibilities and priorities to correspond to the dictates of the recipients of museum services. A change in the mission of a museum, however, never should devalue the scientific collections of the museum or the importance of their curators. It must never be forgotten that collections can exist without museums, so long as the collections are properly maintained



(Van Gelder, 1964), but museums cannot exist without collections (August, 1983).

#### SUMMARY

Administrative hierarchies in American museums reflect the nature of the institutions involved. Hierarchies of large private or public institutions, such as the Carnegie Museum of Natural History, insulate curators from exhibits and from educational and public service functions associated with exhibits. This enables curators to concentrate on their primary functions, curation and research. At universities, education often ranks even higher than curation in terms of priority although research may dominate the time of curators. At large academic institutions, such as Texas Tech University, different functions of museums (for example, research and education) may pertain to different lines of authority in the administrative hierarchy. At smaller academic institutions, such as Fort Hays State University, the chains of command are simpler and priorities of museum personnel depend on the administrators to whom museum directors report.

Departmental museums at universities typically are under the Dean of Arts and Sciences and emphasise undergraduate education. University museums that are under the Vice President for Academic Affairs emphasise both education and research; those that report to the Vice President for Research place the highest priority on graduate education and research; those that report to a Vice President whose role is service to the campus community or maintenance of good relationships with alumni and friends place greater emphasis on service.

Staff hierarchies below the level of curator ideally protect curators from external interruptions and internal routine. Curators should have time to think, plan, make decisions, conduct research, and write; they should not have to answer the telephone, type, number skulls, or perform other tasks that secretaries or technicians could do as well or better.

It is the responsibility of the museum director to perceive the mission of the museum and facilitate accomplishment of goals within that mission. Activities of administrators should enable curators to be more productive because curators are, and should be, the focus of museums. Each curator, first and foremost, is responsible for proper curation and maintenance of the collection in his charge. Moreover, the curator represents the hierarchical level of a museum at which research occurs. Finally, the curator shares his expertise in education and service activities. No other level in the hierarchy of a museum is responsible for so

many of the functions of the museum. Administrators and staff may place demands on the time of a curator, but their activities should free more of the curator's time than they take.

When a new museum is established, it is possible to predetermine its mission and design a hierarchy well suited to that mission. After the mission is determined, persons qualified to perform high priority functions within the mission can be selected for administrative, curatorial, and staff positions. In selection of staff, it should be kept in mind that museums and their personnel must be capable of evolving as the needs of society change. A change in mission, however, should never devalue the collections of the museum or deemphasise the importance of their curators.

#### REFERENCES

- AMADON, D. 1971. Natural history museums—some trends. *Curator*, **14** : 42-49.
- APOSTOLOU, N. G. 1981. Financial accounting and reporting for museum. *Curator*, **24** : 29-39.
- AUGUST, R. S. 1983. Museum: a legal definition. *Curator*, **26** : 137-153.
- BERGMANN, E. 1974. Designing for natural history. *Curator*, **17** : 203-206.
- BOGERT, C. M. 1958. The role of the zoological curator as a writer (with some impertinent digressions). *Curator*, **1**(3) : 48-63.
- CHOATE, J. R., DOWLER, R. C. and ENGSTROM, M. D. 1977. Standards for documentation and data capture for mammals housed in the Museum of the High Plains. *Proc. Mus. High Plains*, Fort Hays State Univ., 31 pp.
- CHOATE, J. R., DOWLER, R. C. and WILHELM, R. B. 1978. Standardized curatorial procedures for the collection of mammals, Museum of the High Plains. *Proc. Mus. High Plains*, Fort Hays State Univ., 23 pp.
- CLARK, C. 1982. Open questions in museum accounting. *Curator*, **25** : 21-39.
- COLBERT, E. H. 1958. On being a curator. *Curator*, **1**(1) : 7-12.
- COMPTON, M. S. 1965. A training program for museum volunteers. *Curator*, **8** : 294-298.

- CONWAY, M. E. 1978. The roles of the curator in natural history museums. *Curator*, **21** : 321-328.
- FLINT, L. 1959. Educational standards and volunteer performance. *Curator*, **2** : 101-106.
- GRINNELL, J. 1922. The museum conscience. *Mus. Wk.*, **4** : 62-63.
- GUTHE, A. K. 1966. The role of a university museum. *Curator*, **9** : 103-105.
- HEINE, A. 1965. The care and feeding of volunteer staff members. *Curator*, **8** : 287-290.
- HUME, R. M. 1969. Progressive innovation: the director's viewpoint. *Curator*, **12** : 14-18.
- INVERARITY, R. B. 1959. Thoughts on the organization of museums. *Curator*, **2** : 293-303.
- NICHOLSON, T. D. 1974. Science and the scientific staff at the American Museum of Natural History. *Curator*, **17** : 173-189.
- PARR, A. E. 1958. The right to do research. *Curator*, **1**(3) : 70-73.
- PARR, A. E. 1962. Origins, nature, and purposes of museum policy. *Curator*, **5** : 217-220.
- PARR, A. E. 1973. On museums and directors. *Curator*, **16** : 281-285.
- REIBEL, D. B. 1974. The use of volunteers in museums and historical societies. *Curator*, **17** : 16-26.
- SCHMIDT, K. P. 1958. The nature of the natural history museum. *Curator* **1**(1) : 20-28.
- SEIDELMAN, J. E. 1965. Importance of volunteer placement. *Curator*, **8** : 299-301.
- VAN GELDER, R. G. 1964. "Another man's position." *Curator*, **7** : 55-71.
- WILLIAMS, S. 1969. A university museum today. *Curator*, **12** : 293-306.

#### DISCUSSION

- Q. How can the ultra complex and unwieldy organisational structure of museums at universities in the U.S. be improved ?*
- A.* The complexity is not a disadvantage if the museum director is compatible with the administrators. It is more important to clearly identify the roles of personnel by their placement in the administrative hierarchy and this can be done with either a complex university hierarchy or businesslike museum hierarchy.

## THE VALUE OF RECENT MAMMAL COLLECTIONS

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### INTRODUCTION

Natural history museums acquire objects or collections for three general purposes or goals. These purposes are to serve the public through programmes of education, exhibits, and research (Ripley, 1973 ; Nicholson, 1983). Natural history museums maintain collections for the express purpose of achieving these goals. Nature centers, on the other hand, are institutions that do not maintain collections for purposes other than exhibition or education (Netting, 1962). Collections in nature centres include items used only for exhibition or education and often little, if any, material is maintained for changing the exhibited or educational items. The real value of collections in a natural history museum lies in their primary use to accomplish these three purposes or goals.

Once collections of natural history specimens are acquired, processed, and curated, they are a non-renewable natural and national resource for the countries which maintain them. In this regard, natural history specimens are like photographs. They each represent something from a point in time that has been captured and preserved for posterity. The natural history specimen represents the material evidence of a specific generation in the evolutionary history of a species. This material evidence of the diversity of nature can never be duplicated nor replaced, and its total value to science and the pursuit of knowledge can never be truly appreciated. These specimens become part of the total resources of a country as well as the museum that cares for them.

### INTRINSIC VALUE

The value of Recent mammal collections can be described as being intrinsic or extrinsic. The intrinsic value derives its worth from the essential nature of the specimens in the collection. Intrinsic value is usually measured in monetary worth. Major natural history museums, such as the Smithsonian Institution, American Museum of Natural History, or the British Museum (Natural History), have millions of specimens in their collections acquired over more than 100 years from all of the far corners of the globe. Many of these specimens are literally worth considerable

sums of money. Generally when asked to list such specimens, the material in the ethnography collections or the specimens of gems, semi-precious stones, and certain minerals in the mineralogy or geology collections come to mind. However, mammal collections also may include specimens of considerable intrinsic value. Tanned furs from any of the fur-bearers such as spotted and other large cats, sea otters, and beaver, or even many of the large ungulates, such as the bison, musk-oxen, yaks, vicuna, and guanaco have an intrinsic value. Although mammals living in more tropical countries do not develop the luxuriant winter fur that is found on mammals in temperate and arctic environments, nevertheless the tanned hides of most of the large- and medium-sized mammals, such as elephant leather, zebra, monkey, antelope, etc., command high prices when used in clothing such as coats and vests, furniture coverings, wall and floor decorations, etc.

Ivory has historically been important in commerce. Jewelry, statuary, and other items made of ivory command high prices. Elephant tusks, hippopotamus teeth, warthog and wild pig tusks, walrus and narwhal tusks, and whale teeth are commonly used. For many years, the canines of American elk have been used in a piece of jewelry for identification by a fraternal lodge. Any museum specimen with teeth consisting of large amounts of ivory is a potential source for commercial exploitation and thus the specimen has intrinsic value.

Many museum specimens consist of parts that can be used for medicinal, religious, or other purposes. The species of rhinos in both Asia and Africa have been over-exploited for their horns. These horns have been regularly used for medicinal purposes and for producing special handles for daggers or knives. In other cultures, ground bone, hair, or dried flesh may be used in producing local medicine. Bones, claws, and hair are used in some cultures for producing religious relicts. The same items may be used for decorating masks or robes for ceremonial use. The carving of bone for jewelry, statuary, and other items has become increasingly popular in many developing countries. The bone can be from either wild or domestic mammals. Most of these items can be obtained from museum specimens as well as in the wild.

Mounted trophies, whether head only, head and shoulder, or whole mounts, may command large amounts of money. Museum collections that include such specimens have an increased intrinsic value. Unique or anomalous specimens may have intrinsic value. Such specimens are usually of historical significance or may exhibit an anomalous anatomical condition.

With their varying amounts of intrinsic value, such specimens from a mammal collection may be sufficient in some cases to justify maintaining

collections in museums. Certainly the intrinsic value of specimens justifies the need on the part of museum administrators to insure that museum personnel adhere to strict codes of ethical behaviour and that well-designed security systems are in practice and adhered to strictly by all personnel and visitors associated with the collection.

### EXTRINSIC VALUE

It is in the extrinsic value of collections wherein the highest justification can be attained for maintaining Recent mammal collections. The extrinsic value of collections allows the natural history museum to achieve its three purposes or goals—namely, education, exhibits, and research.

#### *Education and Exhibits*

Natural history museums have best performed the traditional role of interpreting, exhibiting, and popularising the field of natural science (Squires, 1969). Striking advances are being made in the field of museum exhibition and education. These advances are obvious to anyone who regularly travels to museums. The use of new techniques of exhibit lighting and labelling and of producing foreground materials have allowed for increasingly better and more exciting exhibits. Not only are specimens from the collections used in these exhibits and educational programmes, but the ultimate interpretation and popularisation of the concepts focussed upon in these programmes are made possible by studying specimens and the published materials in the associated libraries. Because of these exhibit and educational programmes, the museum passes from the realm of being only a storehouse for the safekeeping of the material evidence of past generations to becoming centres for visual learning.

As exciting as this may be, however, the need for collections for exhibition and education will always be low. Miller (1929) reported that in June, 1928, the Smithsonian Institution exhibited barely 1,400 of the about 214,000 specimens in the Recent mammal collection. Presently, it is doubtful that any more than that number is exhibited at that institution at any one time even though the mammal collection, now numbering over 600,000 specimens, is the largest in the world (Choate and Genoways, 1975 ; Genoways and Schlitter, 1981 ; Blair, pers. comm.).

#### *Research*

It is in the area of research where the collections have their greatest potential extrinsic value. Specimens are necessary to carry out

collection-oriented or systematic research on mammals. Such research should be the primary research goal of curators of mammal collections and the purpose for which collections are maintained (Netting, 1962 ; Genoways, 1988).

Without question, in order to properly conduct research in systematics, a collection of specimens is required. Netting (1962) reviewed the history of systematic research and its relationship to museums and their collections. He divided the study of natural history into three periods of different time lengths characterised by strikingly different attitudes upon the part of the practitioners of the science and the public. The initial period he referred to as "Practical Systematics" which began roughly two million years ago and ended with Linnaeus in 1735. This period is best characterised by efforts to classify everything for its practical value—what items could be eaten or worn, had therapeutic value, or other uses.

The period of practical systematics was followed by a period of "Descriptive Systematics" from 1735 to 1934. This period dawned with the origin of the binomial system of taxonomic nomenclature or the Linnaean system. During the period, the species category was the centre or focus. Comparative morphology and geographical distribution were used extensively by taxonomists. Probably more than half of the species of living organisms were collected, studied, and described with an incredible amount of this activity taking place during the last half of the nineteenth century under extremely difficult field and laboratory conditions.

The next period he referred to as "New Systematics" Although the change to this period was gradual, the ever increasing study of genetics, especially within populations, changed the appreciation of the species concept by taxonomists. Genetics, ecology, behaviour, biometrics, and karyology, among others, gave deeper insights into the relationships of populations through space and time. Collection-based research was being supplemented with studies of living organisms and multiple systems. The utilisation of collections to supplement research in areas outside of the traditional ones conducted in natural history museums took on new purpose. Collections in natural history museums were no longer merely objects of curiosity that represented organisms brought together from the far corners of the globe and used simply to describe these organisms, often years after they were seen alive.

During this period of New Systematics with the increasingly more sophisticated studies supplementing the traditional taxonomic ones, specimens in museum collections became vouchers used to physically

and permanently document data from these studies. Yates (1985) described a mammalian voucher specimen as necessary to verify the identity of an organism used in another study and, by so doing, assuring the repeatability of the study. In actual fact, the specimens in a museum collection have always served these purposes, although they sometimes only verified the presence of a particular species at a locality and insured that the data on the specimen tag referred to that species. But now the need for vouchers from other studies took on additional gravity. Voucher specimens were classified into three types by Yates (1985): (1) type specimens, upon which names of taxonomic units are based; (2) taxonomic support specimens, specimens of primary importance in taxonomic studies other than nomenclatural studies, such as range extensions and life-history studies; and (3) biological documentation specimens, representative organisms derived from studies or projects other than primarily taxonomic ones such as biochemical studies or environmental impact projects. This latter category of voucher specimens includes most of the material acquired by mammal collections in many museums, especially those in developing countries where applied research projects are being demanded by governmental authorities. Yenbutra (1988) reported that nearly 90 percent of the growth of the more than 9000 specimens of mammals in the collection at the Ecological Research Division of the Thailand Institute of Scientific and Technological Research resulted from voucher specimens taken during ecological research by the divisional staff.

Recent mammal collections have a secondary level of extrinsic value that may, in the span of history, prove to be of even more importance than any others. The collections serve as a resource for future research projects. The specimens and associated data are available for use in research projects that may utilise new techniques or methodology; the sophistication of these techniques or methods depends directly on the ingenuity of future generations of researchers (Lee, 1979). One of the best examples of utilisation of old collections comes from studying organisms other than mammals, but aptly illustrates the point being made here.

Even the most vivid imaginations would not have conditioned the caretaker of the bird collections in Sweden to contemplate the use of collections that Johnels (1973) would develop to assess the impact of mercury in the environment in present-day Sweden. Not having appropriate quantitative data to calculate the level of mercury in the environment, Johnels (op. cit.) measured the level of mercury in feathers in museum specimens of goshawks, ospreys, and great crested grebes collected from 1840 up to the present. A direct correlation could be shown between the mercury content of feathers in goshawks and the introduction of alkyl-mercury as a disinfectant of seeds around 1940.



On the other hand, the mercury content of feathers of ospreys and great crested grebes showed a curve that is parallel to the industrial development in Sweden. Industrial discharges ultimately affect the water environment and, since both of these birds feed on aquatic organisms, the level of mercury in the feathers reflected the increased amounts of mercury in water in Sweden.

In order to counter critics, Johnels (op. cit.) also studied feather replacement in ospreys to show the natural levels of mercury in the environment. Ospreys migrate from Sweden to Africa. Studies of moulting in museum specimens showed that some feathers in adults are replaced in Sweden, some during the winter in Africa, and some enroute. Those feathers replaced in Sweden had high levels of mercury, those replaced south of the Mediterranean had very low levels, and those replaced enroute, roughly two months after leaving Sweden, showed that the mercury could be rapidly eliminated from the body.

Other research projects that may utilise museum collections as a resource are studies of ecology and life history. Again the actual research depends on the ingenuity of the researchers. Parkes (1963) aptly reviewed the incredible amount of information on living birds that could be obtained from collections of bird specimens. An interesting study showing differential migration patterns and onset of migration between males and females of the North American bat *Lasiurus cinereus* was possible from a study of museum specimens by Findley and Jones (1964).

With the increasing attention being given to environmental change and habitat destruction, museum collections are receiving more attention from persons involved in projects designed to assess or monitor such changes. Specimens in museum collections can show what species were present historically, what species might be expected at a site if an inventory was done at present, or, by deduction from the presence or absence of specific species, what type of habitat was present historically versus that existing today.

The geographic distributions of species can be determined from an examination of museum specimens. Persons mapping the distributions of species are often hesitant to accept a geographic record for a particular species, especially if it is one that exhibits taxonomic difficulty in identification, unless that locality record is supplemented with a preserved voucher in a museum collection. Biogeographic relationships can be best studied utilising the specimens maintained in museum collections or the published studies of species distributions resulting from vouchers deposited in these collections.

Numerous disciplines involving research peripheral to Recent mammals utilise museum collections. Studies of the paleontology and zooarchaeology of mammals are absolutely dependent on adequate comparative collections of Recent mammals. These disciplines require an additional dimension in the scope of the mammal collections, namely the presence of synoptic samples of skeletons and fluid-preserved specimens. In addition to the routine need for comparison and identification, a paleontologist may need to know whether some particular aspect of a fossil bone involves a muscle insertion and so must resort to the ultimate dissection of a Recent mammal specimen.

Studies of medical entomology, medical zoology, and parasitology often resort to an examination of Recent mammal specimens to better understand a perplexing phenomenon such as how a leg of a parasite might attach to hair. But routinely, researchers in these areas use the specimens in collections to identify the hosts collected by them in their research. Such hosts should always be deposited in a museum collection as they will add to the body of knowledge of those who will come next for such identifications and serve as a voucher for future verification as taxonomies change.

Mammal collections are extensively used as reference specimens in zoological illustrating and in the field of natural history art. Specimens serve as models to artists working in numerous media of art where natural history subjects are being considered. They also are used by curators of art collections and of ethnography collections to identify objects in older collections. Illustrators of books, field guides, and other similar publications require reference specimens for their work. These specimens are best obtained from museum collections because then, when the illustrations are completed, scientists working with the collections can check the work for accuracy.

Finally, one of the most important uses of a Recent mammal collection is in its use in teaching. Specimens for such purposes should be segregated from the main collections. But every effort should be made to encourage students in zoology to examine and study mammal specimens from a museum collection as the experience can be very exciting for the students and strongly reinforce their interest in studies of whole-organism zoology such as in the fields of ecology, behaviour and ethology, anatomy, taxonomy, etc.

Although collections are the greatest asset of a natural history museum, they can also be their greatest liability (Washburn, 1968; Nicholson, 1983). Few justifications exist for random and unrestricted accumulation of enormous numbers of specimens although such caution should be tempered with the fact that future utilisation of the collections

may be possible in ways not yet contemplated. Costs for obtaining, processing, and maintaining the collections can be considerable. These potential costs must be carefully weighed in consideration of those costs inherent in achieving the goals of the natural history museum.

### SUMMARY

The real value of collections lies in their primary use to accomplish the museum's purpose or goals. Natural history museums generally have three purposes or goals for acquiring objects or collections. These purposes are to serve the public through programmes of education, exhibits, and research. Natural history museums, as opposed to nature centres, maintain collections to achieve these goals. These collections, once acquired, become a non-renewable natural and national resource for countries maintaining them.

Collections of Recent mammal specimens have an intrinsic and extrinsic value. The intrinsic value derives its worth from the essential nature of the specimens. Mammal collections may contain tanned furs; ivory in the form of teeth or tusks; selected parts of specimens usable in medicinal, religious, or other purposes; mounted trophies; and unique or anomalous specimens, all of which have a degree of intrinsic value. These objects, with their varying amounts of intrinsic value, may be sufficient in some cases to justify maintaining collections in museums.

It is in the extrinsic value of collections, however, wherein the highest justification can be reached for maintaining Recent mammal collections in museums. The collections can be used directly as a resource in exhibition and education programmes. But few actual specimens are ever used for such purposes at any given time.

It is in the area of research where the collections have their greatest potential extrinsic value. Specimens are necessary to perform collection oriented or systematic research on mammals. Such research should be the primary research goal of curators of mammal collections and purpose for which collections are maintained. But the value of collections can be expressed by numerous other extrinsic uses. Specimens serve as vouchers for research projects of immediate past and insure that such research can be rechecked or duplicated in the future. These voucher specimens physically and permanently document data in an archival sense.

Collections have a secondary extrinsic value as a resource for future research projects. The specimens and associated data are available

for use in research projects that may utilise new techniques or methodology. They may serve as a resource for studies of ecology and life history, environmental assessment and faunal change, geographic distribution, biogeographic relationships, paleontological relationships and identification, zooarcheology, medical entomology and zoology, and parasitology. They may serve as reference specimens for identification and comparison in zoological illustrating and even natural history art and in introductory training in mammalogy.

Although collections are the greatest asset to a natural history museum, they can also be their greatest liability. Few justifications exist for random and unrestricted accumulation of enormous numbers of specimens. Costs for obtaining, processing and maintaining the collections can be considerable. These potential costs must be carefully weighed in consideration of those costs inherent in achieving the goals of the natural history museum.

#### REFERENCES

- CHOATE, J. R., and GENOWAYS, H. H. 1975. Collections of Recent mammals in North America. *J. Mammal.*, **56** : 452-502.
- FINDLEY, J. S. and JONES, C. 1964. Seasonal distribution of the hoary bat. *J. Mammal.*, **45** : 461-470.
- GENOWAYS, H. H. 1988. Philosophy and ethics of museum collection management. *Proc. Wksp Mgmt Mammal Colln Tropical Environ., Calcutta*, : 5-26.
- GENOWAYS, H. H. and SCHLITTER, D. A. 1981. Collections of Recent mammals of the World, exclusive of Canada and the United States. *Ann. Carnegie Mus.*, **50** : 47-80.
- JOHNELS, A. G. 1973. Role of natural history museums. *Museum*, **25** : 54-59.
- LEE, W. L. 1979. The San Francisco Bay Project: A new approach to using systematics : 249-252. In: *Museum studies and wildlife management, selected papers*. R. C. Banks (compiler and annotator). Smithsonian Institution Press, Washington, D.C.
- MILLER, G. S., Jr. 1929. Mammalogy and the Smithsonian Institution. *Smithson. Instn Ann. Rept*, 1929 : 391-411.

- NETTING, M. G. 1962. Objectives of museum research in natural history. *Mus. News*, **41** : 30-34.
- NICHOLSON, T. D. 1983. The obligation of collecting. *Mus. News*, **62** : 29-33.
- PARKES, K. C. 1963. The contribution of museum collections to knowledge of the living bird. *Living Bird*, **2** : 121-130.
- RIPLEY, S. D. 1973. Museums and the natural heritage. *Museum*, **25** : 10-15.
- SQUIRES, D. F. 1969. Schizophrenia: the plight of the natural history curator. *Mus. News*, **47** : 18-21.
- WASHBURN, W. 1968. Are museums necessary? *Mus. News*, **47** : 9-10.
- YATES, T. L. 1985. The role of voucher specimens in mammal collections : characterization and funding responsibilities. *Acta zool. Fennica*, **170** : 81-82.
- YENBUTRA, S. 1988. Techniques used in the Thai National Reference Collection of mammals. *Proc. Wksp Mgmt Mammal Colln Tropical Environ., Calcutta*, : 397-406.

## **RESOLUTIONS AND RECOMMENDATIONS**

Based on the opinions expressed by participants, the following recommendations were made.

### **1.0 General**

1.1 Having successfully completed the 1st International Workshop on Management of Zoological Collections : Recent Mammal Collections in Tropical Environment, it is hereby resolved that this valuable exercise be continued by convening the 2nd International Workshop at a suitable location within the next three years.

1.2 Considering the complexity of the fauna of the Indian subcontinent and the many decades that have intervened since the last formal mammal survey, it is recommended that a renewed national mammal survey of India be undertaken. Careful consideration should be given to the methodologies to be used in survey work and in localities to be studied.

1.3 In the interest of furthering the knowledge of mammalian fauna of developing nations, it is recommended that professional Taxonomists be given all encouragement and facilities to collect and exchange material with interested sister organisations.

1.4 In developing nations an attempt should be made to establish a centralised reference collection of mammals that would contain, as the ideal condition, representatives of all the mammalian fauna of the respective country. Such a collection should receive governmental support to help in maintenance and in collection expansion.

1.5 Scientific exchange at the broadest possible levels should be encouraged between all nations. This exchange can be most fruitful when scientists engage themselves in cooperative ventures such as research projects, training programmes, or other similar endeavours. Such co-operation offers the most rapid means of exchanging methodologies, recent literature, and other items of importance to scientific advancement.

1.6 The publication of field guides and other semitechnical literature should be considered a priority task of curators. Whenever possible, such field guides should be produced via international cooperation, if such cooperation facilitates the efficient production of these materials. Such guides should be produced in a common language such as English and also in the language of the country and should be inexpensive and readily available to the general public.

1.7 Since basic information on taxonomy and distribution forms the fundamental material for more advanced scientific research an effort should be made to produce an annotated checklist of mammals of the Indian subcontinent. Such a checklist should include a survey of Indian mammal holdings in collections outside of India, as well as a complete survey of the literature on Indian mammals.

1.8 Museum professionals with international interests should formulate a manual of collection management that is truly worldwide in scope taking into account the limited budget and lack of certain materials that characterise many developing countries. The manual should present a step-by-step approach to collection operation that offers practical advice to museum professionals throughout the World.

1.9 Every attempt should be made to update and obtain information on the holdings of mammal collections on a worldwide basis wherever such is not available.

1.10 Type catalogues should be prepared and published. Whenever possible, colour transparencies or photographs should be prepared of all type specimens. Original descriptions should be stored with the type specimens.

## **2.0 Collecting**

2.1 When general collecting is undertaken for small mammals a combination of traps should be used (snap traps, live traps, pitfalls, snares, etc.) to maximise the number of species taken.

2.2 Collectors should try different types of baits to find the most effective baits for particular areas and seasons.

2.3 Visiting roost sites and use of mist nets are the recommended methods of collecting bats.

2.4 Collectors should make special efforts to obtain species with unique habits such as burrowing or arboreal species.

2.5 Collectors should make special efforts to sample all available habitats within an area.

2.6 Field collectors should maintain a catalogue of consecutive numbers for all material collected. They should also maintain notes describing the circumstances under which the specimens were taken. These should become part of the permanent museum records.

2.7 When collecting rare or status indeterminate species consideration must be given to the future survival of the species in nature as well as to providing research materials.

### **3.0 Labelling of specimens**

3.1 Skeletal material should be labelled immediately in the field. The tag should contain at least preparator's name, number and sex of the specimen.

3.2 The specimen label should contain at least certain minimum data entered on permanent labels with permanent ink. These data should include: precise locality data, country, state or province, specific locality, and altitude ; coordinates to specific locality ; date of collection arranged as day, month, and year with month written and not referenced as an Arabic or Roman numeral ; sex ; collector's name and number ; standard external measurements.

3.3 All portions of a specimen should bear the museum catalogue number. This should include all cleaned and dried skeletal material, skin tag, and skull tag.

3.4 Labels with most of the catalogue information should accompany vials or boxes containing skeletal material.

### **4.0 Preparation**

4.1 Use of larvae of dermestid beetles should be encouraged in cleaning skeletal material whenever possible.

4.2 Skeletal material should never be boiled because this causes loosening of teeth, cracking of teeth and bones, warping of bones and cartilage and loosening of cranial sutures.

4.3 Skeletal material for cleaning by beetle larvae should not be poisoned or chemically treated.

4.4 After cleaning by beetle larvae, skeletal material should be washed carefully with the least harmful substances possible, preferably a solution of ammonia and water (1:3).

4.5 In preparation of skins, care should be taken to avoid the use of chemicals that can have a harmful effect on either the skin (especially coat colour), or the preparator. The use of borax or arsenic-bearing compounds is strongly discouraged.



4.6 If a fluid collection is intended for future histological research, the preserving medium must be carefully selected. For example, formalin fixed tissues should be stored in either 70% ethyl alcohol or dilute (5%) buffered formalin. Isopropyl alcohol should not be used.

4.7 A mixture of formalin (9 parts water and 1 part 40% commercial formaldehyde) that is buffered and neutral (pH 7.0) is the best general fixative available and is the fixative of choice for museum mammal collections.

4.8 Tissues should be fixed while fresh, preferably coincidental with the time of death of the specimens.

4.9 Whenever possible, a variety of fixatives should be employed by collectors. This approach maximises the future value of each specimen.

4.10 Fluid collections should be adequately maintained, the preserving solution should be checked and/or replaced at regular intervals.

4.11 Information on fixation procedures should be kept for each specimen.

4.12 Tissues for future research by transmission electron microscopy should be fixed in a trialdehyde solution (glutaraldehyde, acrolein paraformaldehyde).

4.13 Tissues for mt DNA analysis or DNA-DNA hybridisation should be fixed in either 70% ethyl alcohol or frozen in liquid nitrogen after cryoprotection in 10% sucrose.

4.14 Tissues for light level immunocytochemical analysis should be fixed in 4% paraformaldehyde.

4.15 Tissues for isozyme analysis should be fixed by freezing, preferably in liquid nitrogen, and then stored frozen at -75°C.

## **5.0 Collection management**

5.1 New acquisitions should be accessioned by recording the following information as a minimum: accession number, date received, donor's name and address, description, number of specimens, how acquired and remarks.

5.2 Each specimen should receive a unique catalogue number and the following informations should be recorded in the museum catalogue: Catalogue number, accession number, field number, scientific name,

locality, date collected, donor, collector, date catalogued, sex, type of preparation and remarks.

5.3 Museum records such as accession ledgers and catalogues should be kept in a locked fire proof vault or cabinet.

5.4 Specimens should be stored using a simple and logical organisation , all procedures in use should be documented in a written curatorial manual. Extensive labelling throughout the collection promotes efficient use. Constant vigilance should be exercised to correct problems of disorder or damage.

5.5 Specimens should be stored in cases with neoprene or rubber door seals to exclude dust, light, and moisture. Rubber deteriorates and neoprene, therefore, is preferred. Silica gel can be used to lower humidity if mould or mildew is a problem.

5.6 Climate control systems should be installed, wherever possible. Arrangements should be made for a back-up system in case of power failure.

5.7 Holotypes should be deposited in appropriate national institutions offering long-term protection. When a large number of paratypes are available, some of these may be distributed to other appropriate institutions.

5.8 Holotypes should be maintained separately from the general collection and should be identified as such in some distinctive manner (as with red pencil or ink).

5.9 Data standards and curatorial methods for museums should be standardised, as far as possible, at the national if not the international level.

5.10 Specimens should be prepared and regularly inspected in such a way that minimises the likelihood of damage by insects.

5.11 Petroleum jelly or some suitable alternative should be used as a seal on jars of fluid-preserved specimens to prevent evaporation of fluids.

5.12 Paper used for labels for specimens in fluid should resist deterioration.

5.13 Supplies and equipment for collections should be standardised, where possible, so that different institutions can make joint purchases, thereby minimising cost.

5.14 Museum personnel should provide catalogue data on specimens in collections in response to reasonable requests from colleagues from other countries who cannot visit the museum to examine specimens. Such information is secondary and should not be used as primary data.

5.15 Travel and cooperation between museums should involve not only curators and administrators but also skilled technicians.

5.16 Curators world-wide should consider preparation of an international newsletter pertaining to curatorial methods and supplies.

5.17 Cotton or similar fibrous materials should not be used for packing skull vials because it damages the dentition.

5.18 Holotype should not be sent on loan.

5.19 When loaning specimens, every effort must be made to protect them while they are in transit. The preferred method for shipping is wooden containers. Fluid-preserved specimens should be shipped separately.

## **6.0 Pest control**

6.1 Each collection should have a pest control plan. This plan should take into account the safety of the staff as well as the long term maintenance of the collection.

6.2 When the collection area is not air conditioned, all windows, doors, and vents should be screened with wire mesh.

6.3. All incoming materials (such as field collections and loans) should be fumigated upon receipt.

6.4 Good housekeeping must be part of any pest management plan. This includes keeping the collection area clear of unused materials and cleaning around and under cases.

6.5 Insecticides should always be applied by a team of at least two people.

6.6 When fumigating or other application of insecticides is done, the staff should be provided with proper equipment and facilities. There should be a first-aid kit and an emergency plan of action in case of accident.

6.7 The insecticides of choice as of this date are those containing one of the following active ingredients : 2, 2-Dichlorovinyl dimethyl phosphate (DDVP) ; paradichlorobenzene ; pyrethrum methyl carbamate, depending upon the easy availability and proper usage of any or all of them.

## **7.0 Computerisation**

7.1 Computerisation of collection data has many advantages over traditional means of data storage and thus should be considered as a priority item.

7.2 Computerisation should not be attempted without a cost benefit analysis and careful review of available hardware, software, and experiences of those already involved.

7.3 Even if computerisation of a collection is unlikely in the foreseeable future, preparations such as development of standardised data sets should be undertaken as soon as possible.

7.4 To assist with possible “networking” with other countries, data storage should be compatible. Two examples follow :

Month (3 letters)  
↓  
Dates : 30 Sep 1983 ← Year (4 numbers)  
↓  
Day (2 numbers)

Locality : Asia : India, West Bengal, 3 km N, 2 km W Calcutta.

7.5 The minimum mandatory data fields for each specimen are as follows :

- a) Institution identification (museum acronym) ;
- b) Catalogue/serial number ;
- c) Genus
- d) Species ;
- e) Date collected ;
- f) Continent or country ;
- g) State or province ;
- h) Country, district, or major island group ;
- i) Sex ;
- j) Type of preservation ;
- k) Ocean (for marine mammals collected in open water) ;
- l) Sea (for marine mammals collected in open water) ;

- m) Specific collecting locality ;
- n) Preparator's name ,
- o) Preparator's field number ;
- p) Latitude and longitude.

## **8.0 Administrative considerations**

8.1 Once the decision to establish a systematic collection has been made, institutions are committed to properly maintain the collection. This commitment should be binding even if the institution reverses its initial decision, in which case the institution should see that the collection is transferred to another national institution where it will be properly maintained.

8.2 Directors of museums should identify goals for the museums and should ascertain that museum activities are directed towards accomplishment of those goals.

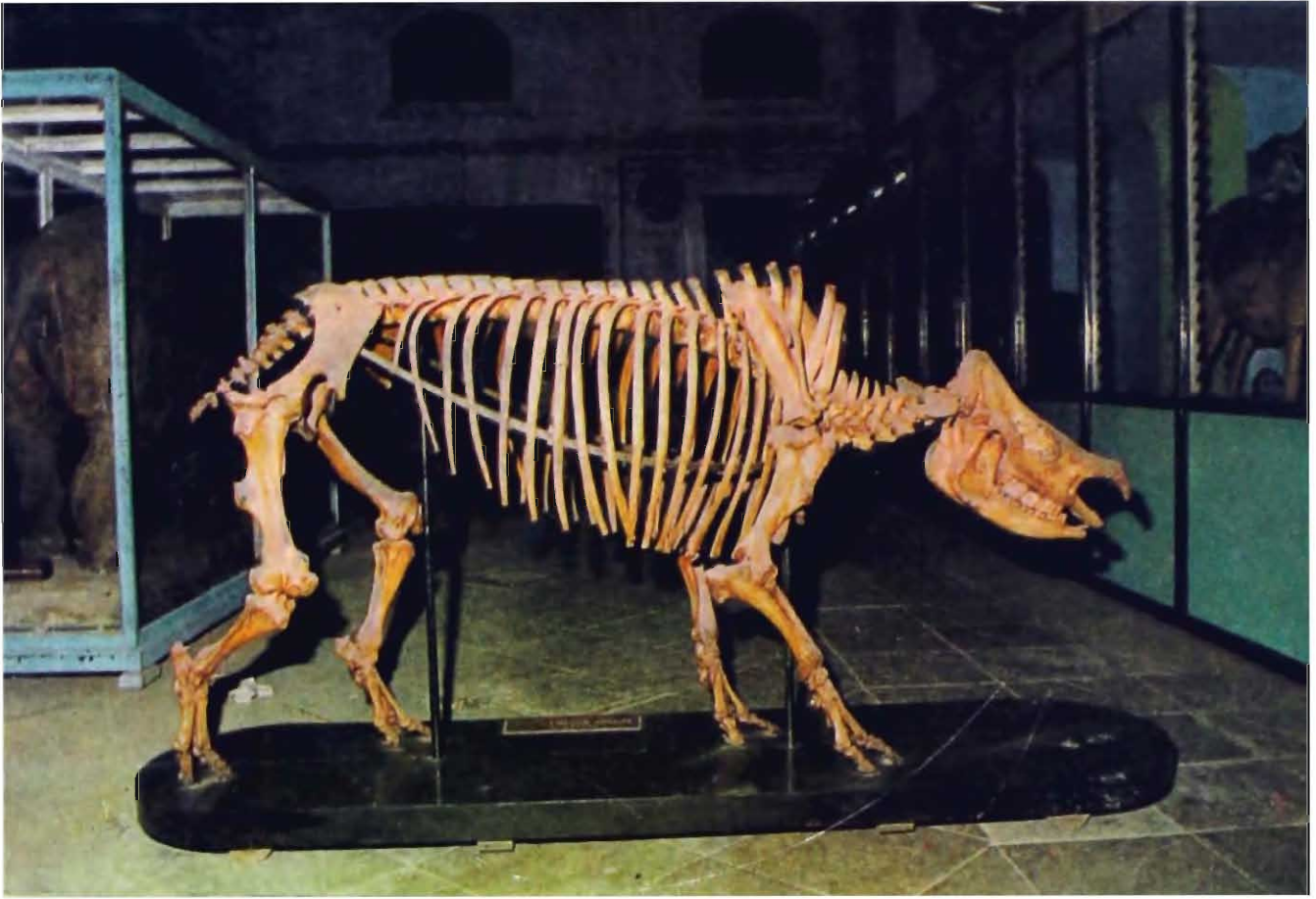
8.3 A change in goals for a museum must never devalue the scientific collections of the museum or the importance of their curators.

8.4 Personnel engaged in management and research on mammalogical collections should have adequate experience as well as qualifications for their positions.

8.5 Each collection should have a curatorial manual in which all standard curatorial procedures are carefully described.

8.6 Museums should have established procedures for fire safety and other potential emergencies.

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ZOOLOGICAL SURVEY OF INDIA